TECHNICAL CONDITIONS OF CONTRACT (TCC)

NAME OF WORK: CIVIL, STRUCTURAL, ARCHITECTURAL AND ASSOICIATED WORKS OF ELECTRICAL BAY BUILDINGS FOR 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2

BHARAT HEAVY ELECTRICALS LIMITED



TECHNICAL CONDITIONS OF CONTRACT (TCC)
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1	SPECIFICATION NO **PE-TS-486-600-C001 (Section C)**		
2	SPECIFICATION NO **PE-TS-999-600-C001 to PE-TS-999-600-C023 (Section-D, Sub-Section D1 to D23)**		

PROJECT: 2X700MWe PHWR- GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA UNIT# 1&2

NPCIL has awarded the work for Design & Engineering, Manufacture, Procurement, Erection/Construction, Commissioning & Testing, Trial Operation and Handing Over of Turbine Island for 2 nos. of 700MWe PHWR (Pressurised Heavy Water Reactor) based Nuclear Power Plants to be set up at Gorakhpur, Haryana.

Project Information is as follows:

	Title	Description
1	**Owner**	NUCLEAR POWER CORPORATION OF INDIA LTD. (NPCIL)
3	**Project Title**	2X700MWe PHWR- GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA UNIT# 1&2 – TG ISLAND PACKAGE
4	**Project Site Location**	Site is situated on the left bank of the Fatehabad Branch of Bhakra canal, in Fatehabad district of Haryana state. The nearest village to the site is Gorakhpur.
5	**Site Access**	Chandigarh, the State capital is about 250 km away from the site by road. National Highway No. 10 passes through Badopal village at a distance of 6 km from site. From Delhi the road to site via NH-10 passes through Rohtak, Hansi and Hisar.
6	**Nearest Railway Station**	The nearest railway station Uklana Mandi (Northern Railway) is about 23km away from the project site.
7	**Nearest Airport**	The nearest major airport is Delhi at about 208 km by road
8	**Nearest Highway**	NH10
9	**Ambient Air Temperatures**	a) Maximum dry bulb temperature : +48.4 deg C, b) Minimum dry bulb temperature: -0.1 deg C, c) Design temperature for electrical equipment /devices: +50 deg
10	**Relative Humidity**	a) Maximum during monsoon : 100% b) Minimum (design) : 5%
11	**Air Quality**	Air quality is clean and free from chemical pollutants.
12	**Rainfall**	a) Annual Average : 512 mm b) Highest annual rainfall : 787 mm in 1997 c) Lowest annual rainfall : 171.1mm in 2000 d) Period : Year 1969-2007

13	**Wind Pressures**	a) Height above mean ground level - @10M Design Wind Speed m/sec - 62.81 b) Height above mean ground level - @100M Design Wind Speed m/sec – 76.14 The assessment of wind loads based on the above basic wind speed shall be done as specified in IS: 875.
14	**Wind Direction**	Predominantly W,SW,NW & SE with respect to true North
15	**Seismology**	Zone III as per IS 1893-2002 part I

Note: - The bidder is advised to visit and examine the site and its surroundings and obtain for himself on his own responsibility all information that may be necessary for preparing the bid and entering into the CONTRACT. All costs for and associated with site visits shall be borne by the bidder.

INSTRUCTIONS TO TENDERERS

The Tenderer are advised to physically visit the site and fully acquaint themselves with site conditions, transportation routes, various distances and the fact that other contractors would be working in this area and their structures are to be protected. The material brought and stacked for construction should not make hindrance to other contractors. **Necessary precaution and arrangements including sprinkling of water during work as acceptable to BHEL for safety & security for the above have to be made by the contractor. No claim will be entertained by BHEL on ground of lack of knowledge and the contractor's rates shall be deemed to have taken this into account.**

The contractor, in the event of this work awarded to him, shall establish an office at site and keep posted an authorized, responsible officer with valid Power of Attorney for the purpose of the contract. Any order or instructions of the `Engineer' or his duly authorized representative, communicated to the contractor's representative at site office will be deemed to have been communicated to the contractor at his legal address.

2.0	**GENERAL SCOPE OF WORK**
2.1	**Scope of this tender covers works for "Civil, Structural, Architectural and Associated Works of Electrical Bay Buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2" AT GORAKHPRUR, HARYANA.**
2.2	The brief scope of work is as follows: The bidder's scope for Civil, Structural & Architectural works of Electrical bay buildings and associated works etc. shall include excavation, dewatering, dressing to required profile, filling, backfilling around completed structures and plinth filling, plinth protection, disposal of surplus earth and rock, concreting including reinforcement and formwork to achieve F3/U3 finish of concrete surfaces, reinforcement cutting bending and placing including preparation of BBS, lapping and tying with binding wires/ reinforcement forging, threading and jointing with couplers (couplers will be supplied by BHEL), water proofing (underground as well as on floors/ roofs), joint and fillers, supply, fabrication and fixing of concrete embedment, foundation bolts etc., grouting, masonry work, plastering, painting, uninsulated/sandwiched roofing, flooring, acid and alkali resistant lining, doors/windows, ventilators, fire proof doors, under deck insulation, false ceiling in all AC areas, lift well, cable ducts/ duct banks, expansion joints, rain water pipe, water supply, sanitary and sewerage works including toilet fittings, insulation, gates/valves, damp proofing, anti-weed and anti-termite treatment, drainage, roads trenches, dismantling of existing RCC structures (if any), final grading and site clearance before handing over to owner / BHEL and other auxiliary items of work, etc. all complete including supply of all materials (except those specified in BHEL scope), consumables, labor, Tools and Plants, transportation and storage, sample testing etc. all complete as per BOQ, specifications and drawings for proper and successful execution of the job for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2.
2.2.1	The scope of work is indicative but not limited to the given below. ➢ The area of work shall be cleared of all vegetation, rubbish and other objectionable matter and materials including dismantling, removing and disposing off the existing underground structures / facilities etc. (if found), shall be disposed of as directed by the Engineer-In-Charge. No separate payment for these operations shall be made. The cost of all these operations

	shall be deemed to have been included in the unit rates rendered for the different items under bill of quantities. ➢ All the works areas shall be adequately flood lighted to the satisfaction of the Engineer-in-Charge when the work is in progress during the night shifts. ➢ The unit rates shall include all material, equipment, fixtures, labor construction plant, temporary works and everything whether of permanent or temporary nature necessary for the completion of job in all respects. ➢ All the BOQ Item rates shall be inclusive of customer's requirements for sampling and testing of construction material, preparation of construction methodology, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/NPCIL as per specification and as directed by engineer - in – charge. ➢ The unit rates quoted for various items of B.O.Q shall include all the stipulations mentioned in Section C "Customer's Project specific technical requirements" and technical specifications under Section D "BHEL's Technical Specifications for execution of various BOQ Items" and nothing extra over B.O.Q rates shall be payable. ➢ Section-C contains two Part i.e. Part-I and Part-II. Part-I of Section-C describes general requirements. Part-II describes specific technical requirement. ➢ Technical specification Section C and Section D shall be read in conjunction with Bill of Quantities. If there is any ambiguity and/or contradiction between Part-I and Part-II of Section-C, the provisions/requirement laid in Part-II shall prevail. If there is any ambiguity and/or contradiction between Section C and Section D, the provisions/ requirement laid in Section C shall prevail. If there is any ambiguity and/or contradiction between Section C and BOQ, the provisions/ requirement laid in BOQ shall prevail. ➢ Drawings showing enough details for the construction as per the specification shall be furnished to the contractor in a phased manner as far as possible. ➢ The bidder should fully apprise himself of the prevailing conditions at the proposed site, climatic conditions including monsoon pattern, local conditions, soil strata and site specific parameters and shall include for all

	such conditions and contingent measures in the bid, including those which may have not been specifically brought out in the specifications
2.2.2	**<u>Cement, Ready Mix Concrete (RMC) and Steel Supply:</u>** Cement, Ready Mix Concrete of desired mix and Reinforcement Steel, HYSD TMT steel of grade Fe-500 confirming to IS:1786 and reinforcement couplers (as per BOQ cum Rates Schedule) required for the tender scope shall be procured by BHEL and issued to contractor free of cost (As FOC Item).
2.2.3	The working area shall be separated from the existing plant area (if required) by cordoning off the area by providing MS / GI sheets of suitable heights with appropriate frame work as approved by BHEL/ Customer. No extra payment shall be paid to contractor for this work.
2.2.4	The Customer NPCIL may depute their representative for checking and supervision of important / various different stages of work. The contractor shall be required to provide all facilities for inspection of works at no extra cost to BHEL. Any defect in quality of work or deviations from drawings / specifications pointed out during such inspection shall be made good by the contractor in the same way as if pointed out by the BHEL Engineer, without any cost implication to BHEL.
2.2.5	The work under this contract shall be carried out as per BOQ Cum Rate Schedule. In case the description / specifications as per BOQ are found to be incomplete, Indian standard / Technical specifications shall be followed. Quantities mentioned in the BOQ cum Rate schedules are approximate only and liable for variation due to change of scope of work / variation in schedule of quantities, changes in design etc. The tenderers shall undertake to execute actual quantities as per advice of BHEL Engineer and accordingly the final contract price shall be worked out on the basis of quantities actually executed at site and payments will also be regulated for the same. The quantities indicated against each item may vary to any extent. Quantity Variations shall be dealt as per GCC Clause No. 2.14.
2.2.6	The complete works shall be carried out as per BOQ cum Rate schedule. If any work covered in the scope of contract cannot be executed using items available in BOQ, additional / extra items shall be made and rates for such items shall be worked out as per GCC clause 2.15.7. However contractor shall be bound to execute all the works under the scope of the contract and decision whether an extra item is applicable or not, shall be taken by BHEL Engineer which will be binding on the contractor.
2.2.7	Any activity which is necessarily required for satisfactory execution of any item of BOQ in line with technical specifications shall be deemed to be included in

	BOQ item even if it is not described in the item description and no extra payment shall be made against such activity.
2.3	**The technical requirements for work to be executed under this specification shall be as per PE-TS-486-600-C001 (Section C) & PE-TS-999-600-C001 to PE-TS-999-600-C023 (Section-D, Sub-Section D1 to D23) enclosed with this tender document. (Part - II)**
2.4	**Contractor's scope also includes following:**
2.4.1	Furnishing all labor, materials (except those specified in BHEL scope), supervision, construction plans, equipment, supplies, transport to and from the site, materials handling, fuel, electricity, compressed air, water, transit and storage insurance and all other incidental items and temporary works not shown or specified but reasonably implied or necessary for the proper completion, maintenance and handing over the works, in accordance with the stipulations laid down in the contract documents and additional stipulations as may be provided by BHEL Engineer during the course of works.
2.4.2	Furnishing samples of all materials required by the engineers for testing / inspection and approval for use in the works. The samples may be retained by the engineer for final incorporation in the works. Furnishing test reports for the products used or intended to be used, if called for the specifications or if so desired by the engineer.
2.4.3	Giving all notices, paying all fees, taxes etc., in accordance with the general conditions of contract, that are required for all works including temporary works.
2.4.4	Arranging manufacturer's supervision for items of work done as per manufacturer's specifications when so specified.
2.4.5	The scope of work will also include such other related works although they may not be specifically mentioned in the above paragraph and all such incidental items not specified but reasonably implied and necessary for completion of the job as a whole all as desired and as directed by the engineer.
2.4.6	The scope of work covered above is not a comprehensive list of items of work involved. The detail scope of work may vary considerably depending on the actual construction requirements.
2.4.7	The work covered under this specification is of highly sophisticated nature requiring the best quality of workmanship, engineering and construction management. The contractor should ensure timely completion of the work. The contractor must have the adequate quantity of tools, construction aids, equipment, etc., in his possession. He must also have on his rolls adequate trained, qualified and experienced supervisory staff and skilled personnel.

2.4.8	Contractor shall comply with the instructions of given by the Customer's (NPCIL) departmental safety officer or his representative(s) regarding safety precautions, protection measures and housekeeping etc.
2.4.9	The contractor shall comply with all provisions of "AERB Safety Guide for Works contract" Document No. AERB/SG/IS-1 and other safety requirements as applicable to site.
2.4.10	The Contractor shall meet statutory requirements as well as regulatory requirements applicable to the project, in general, and NPCIL in particular, especially the requirements as per Factory Act-1948 (amended in 1987), Atomic Energy Factories Rules-1996 (AEFR-1996 or latest version available at the time of work execution), safety guidelines for Job Hazard Analysis (JHA) & AERB Notifications on Industrial and Fire Safety. The copies of the same can be obtained from NPCIL on request.
2.4.11	**HOUSEKEEPING:** Housekeeping is very essential to provide safe working area for construction personnel and for movement of the machineries. In order to achieve this objective; a two part housekeeping policy is adopted at GHAVP. As first part contractor must maintain certain housekeeping practices for his own works. In addition to this, for up keeping overall plant area and areas where multiple agencies work simultaneously, different package contractors shall be responsible for maintaining general housekeeping in the specific allotted area to them. Housekeeping of own works assigned area/building and other procedure and work shall be in accordance with clauses mentioned below:
2.4.11.1	**Housekeeping of own works:** i) The Contractor shall at all time keep his work spot, site office, workshops and surroundings clean and tidy from rubbish, scrap, surplus materials and unwanted tools and equipment. ii) Welding and other electrical cables shall be so routed to allow safe traffic by all concerned. Cables shall not be spread on floor; it shall be properly supported and clamped along the wall. iii) No materials on any of the sites of work shall be so stacked or placed as to cause danger or inconvenience to any person or the public. The Engineer-In- Charge may require the Contractor to remove any materials which are considered to be of danger or cause inconvenience to the public. In case Contractor fails to comply with the instruction of Engineer-In-Charge, he may get the work done at the risk and cost of Contractor. iv) The Contractor shall on day to day basis have removed from the work

place all unwanted scaffoldings, surplus materials, rubbish, etc.

v) The Engineer-In-Charge has the right to stop work if the Contractor fails to improve upon the housekeeping after having been notified.

vi) In addition, the Contractor shall comply with specific housekeeping requirements given in tender specification.

2.4.11.2 Housekeeping of the assigned area / Building:

During the entire phase of execution of contract till facilities are taken over by NPCIL (which also includes extended period of contract, if any), it shall be the responsibility of the Contractor to maintain general cleanliness in the area assigned to him. The contractor shall estimate the total area for two nos. of Electrical Buildings based on the approved final layout.

2.4.11.3 General description of work :

SL. NO.	OPERATION	MINIMUM FREQUENCY OF OPERATION
1.	Cleaning and Sweeping of all floors, staircase, platform, lifts and wiping of handrails, equipment, JBs, pipes and etc.	Daily
2	Wet mopping of finished floors.	Weekly
3	Vacuum cleaning of finished floors.	Monthly
4	Debris removal from dust bin, baskets placed in the respective building.	Monthly or as and when required

2.4.11.4 Procedures for execution of work:

i) Cleaning and sweeping of floors, staircase, platform, anything and everything up to ceiling height and ceiling, as per the frequency indicated in the table. Cleaning activity shall start in the morning at 7.00 AM so as to complete all the cleaning/ moping work before 9.00 AM

ii) Continuous sweeping to be done at entrance of building and cleaning/ wiping of equipment and systems located at various floors of the building during working hours with lunch break and tea break.

iii) Removal of cobwebs, putting the collected debris other than structural materials in the dustbin kept at the specified location on every day basis. Disposal of collected structural materials within a distance of 1.5 Km on daily basis.

iv) Lifting, carrying and disposal of all generated debris such as structural pieces, cable pieces, cable trays, ducts, wooden pieces, packing materials, piping material etc. and all other generated scrap from allotted building within a distance of 1 Km on daily basis.

	v) Disposal of debris from dust bins/baskets placed in the respective building within a distance of 1 Km once in a monthly basis or as and when required. vi) In order to maintain quality services and minimize operational problems, the Contractor must rotate the staff once in six months with prior written intimation to Engineer In Charge. vii) The Contractor shall arrange his own equipment's and tools required for this work like trolleys, ladders, buckets, dust bins, brooms, industrial vaccum cleaner, brushes, wiping cloths or any other material required for the cleaning. viii) The storage and security of his materials and equipment shall be the sole responsibility of the Contractor and shall have no right to claim for any loss/theft or damage of the same. ix) The exclusive work force shall be deputed for the this work and work force deployed for this general housekeeping shall not be diverted for any other job or for his own house keeping jobs. x) All deployed work force shall be provided with dress (with proper code), safety and cleaning gears and in no case work should stop for want of gears. xi) The Contractor shall make his own arrangements of water required to execute this job. Providing work force / staff: The Contractor shall deploy adequate housekeeping and supervisory manpower at his own account & responsibility. At the time of allotment of the area for up keeping, the name of NPCIL officials in charge for housekeeping, herein after referred as "Area in charge" (AIC) of the area will be conveyed to the Contractor.
2.4.11.5	**Reporting:** i) The Housekeeping Supervisor(s) should report daily to the AIC & take day-to-day instructions. ii) The Contractor shall make sure that Housekeeping Supervisor(s) is necessarily available during working hours for receiving & implementing the Instructions of the AIC. iii) It shall be the responsibility of the Contractor to get the attendance of the housekeeping staff verified by AIC. iv) The weekly/fortnightly/monthly jobs should be planned by Housekeeping Supervisor(s) in consultation with AIC in such a manner

	that these are spread over the entire week and done during office hours. v) However, certain jobs will necessarily be carried out during Sundays, for which instructions should be taken by the Housekeeping Supervisor(s) from AIC. vi) Proper registers/records of the jobs carried out on daily, weekly, fortnightly and monthly basis will be maintained by the Housekeeping Supervisor(s) and will be countersigned by the AIC on daily basis and finally at the end of each month by ENC. vii) Housekeeping Supervisor shall remain in his area most of the time and shall have information about agencies working/ material stacked in his area. Suitable control system may be devised for the same. viii) The Contractor shall be equipped to handle the special/emergency services even at short notice. ix) All equipment deployed shall be of quality standard. x) Housekeeping Supervisor shall not allow those materials which affect the up keeping and fire hazards to building. Ex: wooden planks, drums, scaffolding materials which are not painted.
2.4.11.6	**Unsatisfactory performance and consequence thereof:** Before commencement of job the Contractor shall submit procedure, manpower list and work plan on housekeeping of respective building under his control and he will follow the same. Monitoring of the levels of Quality of the housekeeping services shall be done on regular basis by BHEL as well as Customer's AIC. In the event of unsatisfactory service or any failure at any time on the part of Contractor as reported by Customer (who shall be the sole judge and whose decision shall be final), the Contractor shall be liable to be penalised and accordingly deductions as determined by Engineer-In-Charge in a rational manner shall be made from the dues of contractor payable against Area housekeeping work. Following penalties shall be imposed for Area House Keeping Work: • Non-deployment/Improper maintenance of toilets shall be liable for penalty of Rs. 500 per toilet per day. The Contractor shall at all times ensure that his performance is satisfactory, failing which, BHEL shall be at the liberty to get the affected work done through any other agency, at the risk and cost of the Contractor and all expenses incurred on this account shall be recovered from RA bill

	Note: Contractor shall note that BHEL is liable to its customer (NPCIL) for following all norms and guidelines regarding safety and housekeeping as specified in the tender or as provided by NPCIL during course of execution of contract. Inter-Alia, BHEL's contractor deployed at NPCIL site will also be regulated under the same norms/guidelines and has to provide all safety and housekeeping requirement as specified by customer (time-to-time). In case of contractor's failure to provide such materials/ services and consequently if any penalty/recovery is imposed by Customer (NPCIL), same will be recovered from the due payments (Bills) of the contractor.
2.4.12	**ENTRY OF CONTRACTOR'S PERSONNEL AND VEHICLES**
2.4.12.1	The construction site is within the purview of authorized security force. The contractor shall follow at site all security rules as may be framed by the Corporation from time to time regarding removal/movement of materials and equipment from site, issue of biometry RFID identity cards, control of entry of personnel and all similar matters. Contractor shall also follow all rules and regulations applicable to the area being declared / pronounced from time to time by the authorities or state authority having sensitive structures within the vicinity of the site. Nothing extra will be payable on account of stoppage/hindrance of the work. *The contractor shall get the gate passes for their workers issued by Security agency deployed by NPCIL.* The identity cards/passes will be issued to the Contractor's staff and labour by NPCIL. A refundable amount as notified from time to time by NPCIL, shall be charged for issuing these cards. However all such cards shall be essentially retuned back to NPCIL on completion of work or when the individual card holder leaves the site. In case contract workers leave in between i.e. before the expiry of contract completion date, the contactor must inform the same to EIC &Security agency so that suitable remark can be added in the computer record for future checking. The contractor has to ensure deposition of gate pass issued to such worker to issuing authority through Engineer-In-Charge at the earliest. In general, RFID cards with hand geometry shall be applicable for all the contract personnel and workmen. However, till the system for issue of RFID cards with hand geometry is established for, normal photo gate passes shall be issued. In case of damage or loss of RFID card a penalty of Rs. 200/- per card shall be imposed and recovered from the RA bill.
2.4.12.2	**Procedure for issue of gate pass is as below:**

	i. Temporary passes will be issued for an initial period of 15 days on the basis of photo identity on recommendation of Customer's Engineer-In-Charge based on request & certification of contractor. Following forms of photo identity shall be acceptable for issue of initial gate passes to contract personnel and workmen. ▪ Voter ID card / Diving License / Passport /Photo bearing ration card/Aadhar Card. ▪ Letter from the following in their letter head with attested photo and individual's details. o Village Administrative officer o Elected Councilor o Panchayat President o Member of Legislature Assembly (MLA) o Member of Legislature Council (MLC) o Member of Parliament (MP) o Tehsildar ii. Thereafter, renewal of above temporary gate passes will be done for a period of further two months after having completed safety induction training, first aid training and submission of medical fitness certificate. iii. The Contractor shall submit the **police verification certificate (PVC)** for his staff and labour as a pre-condition to issue of RFID cards. On receipt of PVC, RFID card shall be issued upto a period of one year or remaining contract period, whichever is less. In between, each of contractor's employee has to undergo safety training after every 6 months, which shall be coordinated by BHEL's Head (Safety) & NPCIL Head (IS&F)]. After expiry of this one year duration, gate passes shall be further renewed as per the same guidelines. iv. In case of receipt of any adverse information against an individual, the issued identity card shall be immediately cancelled and contractor has to surrender it with Security Agency. v. Separate permission will have to be obtained by Contractor for entry of personnel, equipment's & material in night shift and also for Sunday / Holidays. Permission for vehicles will be given for a period of six months or expiry of contract, whichever is earlier based on the recommendation of Customer's Engineer-In-Charge, after verification of relevant documents.

	The contractor and his employees shall not disclose any information or drawings furnished to them by the BHEL/ Customer. Any drawings, reports and other information prepared by the contractor/by BHEL and/or NPCIL or jointly by both for the execution of the contract shall not be disclosed without the prior written approval of the Engineer. No photographs of the works or plant within the site premises shall be taken. On completion of work, contractor has to surrender all identity cards issued under the contract for their labour / staff to Issuing authority and a No Dues Certificate has to be submitted to Engineer-in-Charge of work before final bill payment.
2.4.13	Where ever the Supply & Erection together is covered in the scope of bidder necessary approvals from BHEL / NPCIL shall be taken by bidder for the design, inspection procedure & vendor. List of items for which such approvals required will be frozen during execution of the contract. **NOTE: 1. Contractor shall procure and supply the items to project site as per the BOQ from BHEL / NPCIL approved vendors, meeting the specification, Drawings and instructions of the Engineer.**

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.1.0	**ESTABLISHMENT**			
3.1.1	**FOR CONSTRUCTION PURPOSE:**			
A	Open space for office	Yes		BHEL may provide free of charge limited open space for office and store as and where made available by its customer. Also refer clause no. 3.8.1
B	Open space for storage	Yes		
C	Construction of bidder's office, canteen and storage building including supply of materials and other services		Yes	
D	Bidder's all office equipment, office / store / canteen consumables		Yes	
E	Canteen facilities for the bidder's staff, supervisors and engineers etc.		Yes	
F	Firefighting equipment like buckets, extinguishers etc.		Yes	
G	Fencing of storage area, office, canteen etc. of the bidder		Yes	

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.1.2	**FOR LIVING PURPOSES OF THE BIDDER**			
A	Open space		Yes	Bidder to arrange land outside the plant boundary for their labor accommodation. Basic sanitation and cleanliness of labour colony is to be maintained by bidder at no extra cost to BHEL. NPCIL (customer)/ BHEL shall have regular visit at labour colony for inspection of cleanliness and sanitation, if any penalty is given to BHEL by NPCIL towards the labor colony sanitation or for any other reasons, same shall be deducted from the bidder from their due payments because scope of establishing labor colony as per the statutory requirements and NPCIL requirement, is in the scope of bidder only.
B	Living accommodation		Yes	
3.2.0	**ELECTRICITY**			

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.2.1	Electricity For construction purposes **(To be specified whether chargeable or free)**		**Yes**	Construction Power can be provided at single point source on **chargeable basis** as and when made available by Owner, however bidder has to deploy DG Sets at no extra cost to BHEL.
3.2.1.1	Single Point source	**Yes**		
3.2.1.2	Further distribution for the work to be done which include supply of materials and execution		Yes	
3.2.2	Electricity for the office, stores, canteen etc. of the bidder which include:		Yes	
3.2.2.1	Distribution from single point including supply of materials and service.		Yes	
3.2.2.2	Supply, installation and connection of material of energy meter including operation and maintenance.		Yes	
3.2.2.3	Duties and deposits including statutory clearances for the above.		Yes	
3.2.2.4	Living facilities for office use including charges.		Yes	

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.2.2.5	Demobilization of the facilities after completion of works.		Yes	
3.2.3	Electricity for living accommodation of the bidder's staff, engineers, supervisors etc. on the above lines**.**		Yes	
3.3.0	**WATER SUPPLY**			
3.3.1	**For construction purposes:**			
3.3.1.1	Making the water available at single point	**Yes**	Yes	Construction Water can be provided at single point source on **chargeable basis** as and when made available by Owner. However, bidder has to make an arrangement for construction water at his own cost by resorting to the methods like water tankers, etc.
3.3.1.2	Further distribution as per the requirement of work including supply of materials and execution		Yes	
3.3.2	**Water supply for bidder's office, stores, canteen etc.**			

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.3.2.1	Making the water available at single point	**Yes**	Yes	Construction Water can be provided at single point source on **chargeable basis** as and when made available by Owner. However, bidder has to make an arrangement for water at his own cost by resorting to the methods like water tankers, etc.
3.3.2.2	Further distribution as per the requirement of work including supply of materials and execution		Yes	
3.4.0	**LIGHTING**			
3.4.1	For construction work (supply of all the necessary materials) 1. At office storage area 2. At the preassembly area 3. At the construction site /area		Yes	

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.4.2	For construction work (execution of the lighting work/ arrangements) 1. At office storage area 2. At the preassembly area 3. At the construction site /area		Yes	
3.4.3	Providing the necessary consumables like bulbs, switches, etc. during the course of construction.		Yes	
3.4.4	Lighting for the living purposes of the bidder at the colony / quarters		Yes	
3.5.0	**COMMUNICATION FACILITIES FOR SITE OPERATIONS OF THE BIDDER**			
3.5.1	Téléphone, internet, intranet, e-mail etc.		Yes	**Please Note:** Smart Mobile phones are prohibited in this plant. Contractor to use Basic phones **OR** other instruments for communication purposes as per NPCIL guidelines.
3.6.0	**COMPRESSED AIR SUPPLY**			

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.6.1	Supply of Compressor and all other equipment required for compressor and compressed air system including pipes, valves, storage systems etc.		Yes	
3.6.2	Installation of the above system and operation and maintenance of the same.		Yes	
3.6.3	Supply of the all the consumables for the above system during the contract period		Yes	
3.7	**CONSTRUCTION FACILITIES**			
3.7.0	Engineering works for construction:			
3.7.1	Providing the construction drawings for all the works covered under this scope	Yes		
3.7.2	Drawings for construction methods and detailed shop drawings	Yes	Yes	In consultation with BHEL. Detailed shop drawings shall be prepared by the Contractor as specified in the BOQ

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	Bidder	
3.7.3	As-built drawings – where ever deviations observed and executed and also based on the decisions taken at site.		Yes	In consultation with BHEL
3.7.4	Shipping lists etc. for reference and planning the activities	Yes	Yes	”
3.7.5	Preparation of site construction schedules and other input requirements		Yes	”
3.7.6	Review of performance and revision of site construction schedules in order to achieve the end dates and other commitments	Yes	Yes	”
3.7.7	Weekly construction schedules		Yes	”
3.7.8	Daily construction / work plan		Yes	”
3.7.9	Periodic visit of the senior official of the bidder to site to review the progress so that works are completed as per schedule. It is suggested this review by the senior official of the bidder should be done once in every month.		Yes	
3.7.10	Preparation of Fabrication Shop and preassembly bay as per NPCIL requirement		Yes	

3.8	**Other important Conditions regarding facilities to be provided by BHEL / Contractor:**
3.8.1	BHEL may provide free of charge limited open space, for office & storage shed, as and where made available by Customer (NPCIL). It is the responsibility of the contractor to construct sheds, fabrication shop, provide all utilities and dismantle and clear the site after completion of work or as and when required, as a part of his scope of work.
3.8.2	Contractor shall be responsible for providing all necessary facilities like residential accommodation, transport, electricity, water, medical facilities etc. as required under various labour laws and statutory rules and regulations framed there under to the personnel employed by him.
3.8.3	Provision of distribution lines of power and water from the central points to the required place with proper distribution boards observing the safety rules laid down by the authorities of the state shall be done by the contractor, supplying all the materials like cables, distribution board, switch boards, TPN, CBS, ELCBS/ MCCBS / Copper / Brass clamps, copper conductor, change over switches, pipes etc. at his own cost. If any failure is caused in supply of the power and water, it is the responsibility of the contractor to make alternate arrangements at his cost. The contractor shall adjust his working shift / hours accordingly and deploy additional manpower if necessary so as to achieve the targets.
3.8.4	In case of power cuts / load shedding no compensation for idle labor or extension of time for completion of work will be given to contractor.
3.8.5	Adequate lighting facilities in line of Rule -11 of Atomic Energy (Factories) Rules 1996 for building and outside area such as flood light, hand lights and area lighting shall be provided by the contractor at his own cost at the site of construction, at the storage of his materials and equipment and at temporary access roads within the working area. The contractor shall obtain the approval of Engineer-In-charge for the lighting arrangement prior to installation.
3.8.6	No claim for damages will be entertained by the Company on account of interruptions of water supply or limitation of quantity of water as aforesaid or on account of the water so taken being not fit for construction purposes or on any other account in connection with such water supply.

3.8.7	Contractor to satisfy himself that the water drawn by him is fit for construction / consumption and adequately treat such water at his cost when it is not found fit for the said purposes.
3.8.8	The Contractor should make arrangements for storage of sufficient quantity of water required for work.
3.8.9	The rate of recovery against Water Supply, if provided by Customer (NPCIL) under this contract shall be as per rates notified by HI & WRD (Haryana Irrigation and Water Resource Division) from time to time. The contractor shall give his peak and average requirements. In case, adequate quantity of construction water is not supplied by Customer (NPCIL), the Contractor shall make his own arrangement to draw water from the primary source at his own cost.
3.8.10	To ensure adequate water supply at all levels on the works for the purpose of construction, he shall install necessary pumps, for delivery of water at all levels with requisite pressure. Water supply scheme proposed by the contractor shall be subjected to the approval of the Engineer-in-charge. The contractor shall provide necessary number and capacity of electrical/diesel operated high lift pumps to ensure supply of water at the highest point of the structure. To ensure uninterrupted water supply in the event of power failure, contractor shall install diesel pumps as a standby measure. The contractor shall ensure availability of potable quality of water as specified in the specifications. No boreholes for drawl of the water from the primary source shall be allowed in plant site. It is to be clearly understood that disruption in water supply or non-availability of water shall not entitle the contractor for any claim for compensation in time and/or money.
3.8.11	The contractor shall make his own arrangement for drawl, supply, distribution and maintenance of water for labor camp. No land, water, electricity etc. will be provided by BHEL and Customer (NPCIL) for labor camp.
3.8.12	The rate of recovery against Power supply shall be as follows: a) Rates notified by DHBVN (Dakshin Haryana Bijlee Vitaran Nigam) from time to time. b) Per Month, minimum charges @ Rs. 160/kVA (Connected Load)/ per month. However for un-interrupted execution of site works during power shutdown/ system break-down periods, the contractor at his own cost shall arrange power through alternate sources.

3.8.13	Recoveries for the power supplied for construction purposes at Plant site shall be made from running account bills of the contractor on the basis of actual consumption with minimum charge @ Rs.160/kVA (Connected Load)/maximum demand per month.
3.8.14	The contractor shall maintain a power factor at not less than 0.9 by installation if necessary at his own cost suitable corrective devices. The contractor's failure in this regard within a period as stipulated by the Engineer-in-Charge may entail installation of the necessary corrective device by the Engineer-in-Charge at contractor's risk and cost.
3.8.15	Contractor's seeking connection of capacity 50kVA or more shall be required to install tri-vector energy meter for power factor calculation purpose. He shall also be required to install power factor corrective device. In case contractor fails to provide tri-vector meter for some time or tri-vector meter becomes faulty, it will be assumed that contractor have consumed power at 0.6 P.F. and surcharge shall be charged on this power factor as per above clause.
3.8.16	The Contractor shall during the progress of the work, provide, erect and maintain at his own expenses all necessary temporary workshops, stores, consumables, offices, etc. required for the proper and efficient execution of the work. The planning, setting and erection of these buildings shall have the approval of the Engineer and the Contractor shall at all times keep them tidy and in a clean and sanitary condition to the entire satisfaction of the Engineer.
3.8.17	On completion of work or as and when required by BHEL, all the temporary buildings, structures, pipe lines, cables etc. shall be dismantled and leveled and debris shall be removed as per instruction of BHEL by the contractor at his cost. In the event of his failure to do so, same will be got done by the Engineer and expenses incurred shall be recovered from the contractor along with prevailing overhead. The decision of BHEL Engineer in this regard shall be final.

(A) - LIST OF T & Ps TO BE ARRANGED BY THE CONTRACTOR AT HIS OWN COST:

Sl No.	EQUIPMENT	INDICATIVE QUANTITY
1	HYDRA/ LIGHT CRANE of Min. 14 T	2 Nos.
2	SUBMERSIBLE PUMP (DIESEL / ELEC)	3 Nos.
3	PLC OPERATED BATCHING PLANT WITH PRINTING FACILITY (MIN 10 **CUM** PER HOUR).	APR* (Instead of setting up his own batching plant, contractor can also tie-up with other Vendor's inside the project premises for his requirement of Soil-Cement mix etc.) **Note:** Ready Mix Concrete production, transportation and placement for contract's scope is in BHEL's RMC agency's scope, RMC will be procured by BHEL and issued to contractor as F.O.C. Item.
4	Tower Crane (Capacity 20 MT and approx. reach of 50 m (radius)).	2 Nos.
5	TRANSIT MIXER (6M3 CAPACITY) WITH MATCHING DUMPERS	APR*
6	15/20 MT TRAILORS WITH PULLING UNIT / TRACTOR – TRAILORS	2 Nos.
7	SLUDGE / SLURRY PUMP (DIESEL / ELEC)	2 Nos.
8	REINFORCEMET CUTTING / BENDING MACHINE	3 Nos.
9	REINFORCEMENT FORGING AND THREADING MACHINE FOR COUPLER CONNECTIONS	02 Nos.
10	PORTABLE LIGHTING MAST / LIGHTING SYSTEM	6 Nos.
11	CEMENT STORAGE SHED	APR*

12	DE WATERING PUMP – 5HP/10HP/20HP	1 No. EACH
13	PORTABLE CONCRETE MIXTURE M/C	APR*
14	ARC WELDING MACHINES	APR*
15	PLATE COMPACTOR	APR*
16	PNEUMATIC JACK HAMMER	APR*
17	MECHANIZED MODULAR UNITS OF SCAFFOLDING	APR*
18	PLY SHUTTERING BOARD/ STEEL SHUTTERING WITH ADEQUATE SUPPORTING STRUCTURE FROM DOKA/ARCOW OR EQUIVALENT	APR*
19	HYDRAULIC EXCAVATOR/POCLAINS	APR*
20	JCB	APR*
21	DUMPERS	APR*
22	DOZERS	APR*
23	AIR COMPRESSOR	APR*
24	DG SET 62.5 kVA	APR*
25	WATER TANKER WITH SPRINKLER	APR*
26	VIBROMAX/EARTH COMPACTOR	APR*
27	WATER TANKER-4000 LTR. CAPACITY	APR*
28	FIRE EXTINGUISHER'S	APR*
29	ELECTRIC/ DIESEL OPERATED CONCRETE VIBRATORS WITH ADEQUATE NEEDLES IN VARYING SIZES I.E. 20MM, 40MM, 50MM AND 60MM ETC.	APR*
30	DRINKING WATER TANK-2000 LT.	APR*

31	GROUTING PUMP WITH ALL ACCESSORIES AND FITTINGS	2 Nos./Additional as per requirement

APR*: As per Requirement

NOTEs:

1. The above list – (A) is only indicative and these T&Ps may not be required for entire contract period but contractor will ensure that these T&Ps are provided as per the work requirement. **T&P Deployment schedule will be finalized at site based on the work fronts and in consultation with BHEL Engineer. Contractor have to mobilize / maintain the T& P as per the schedule notified time to time by BHEL Engineer.**

2. If any one of T&P mentioned above is not needed for proper execution of scope of work, provided contractor has not utilized BHEL free issued T&P for completing such work, no recovery from contractor shall be applicable.

3. Any additional item required in addition to above mentioned T&P for proper execution of scope of work, contractor has to arrange such T&P within quoted rate on the instruction of BHEL in writing in a reasonable period within two weeks from the written instruction from BHEL.
4. In case deployment of T&P w.r.t requirement, is delayed or deployed for a shorter period or abnormal down time of T&P or in case T&P w.r.t requirement was not deployed by the contractor as per instruction of BHEL and BHEL had to deploy either its own T&P or from outside, the recovery shall be done from the contractor as under:

    a. In case BHEL had to deploy its own T&P, hire charges of T&P applicable for outside agencies as per extant guidelines for "Hire Charges on issue of Capital Tools & Plants" shall be recovered.

    b. In case BHEL had to deploy the T&P from outside, actual hiring cost plus applicable overheads shall be recovered.

5. All the tools and tackles/measuring instruments shall be duly tested/calibrated and valid certificate to that effect should be submitted to BHEL site in-charge before the start of work.

6. Other terms and conditions regarding above items please also refer clause for T&P/IMTEs in SCC.

7. All the tools and plants required for this scope of work, except the Tools & Plants provided by BHEL are to be arranged by the contractor within the quoted rates. The list is suggestive in nature. **Any additional T & P required to meet BHEL commitments/schedule shall be arranged without any extra cost by the contractor.**
8. All the T&Ps/ measuring instruments required for the scope of work shall not be more than 3 years old and in good working condition.
9. **If the work related to T & Ps mentioned above list - (A) is completed then, Engineer-In-Charge can release the T&P during contract period / extended period if any. However, written permission shall be taken by contractor from BHEL construction Manager before releasing T&P.**

B- LIST OF IMTEs/MMEs REQUIRED:

SL NO	EQUIPMENT
1	TOTAL STATION
2	AUTO LEVEL AND STAFF
3	COMPRESSION STRENGTH TESTING EQUIPMENT
4	CONSTRUCTION MATERIAL TEST EQUIPMENT
5	EARTH COMPACTION TEST EQUIPMENT
6	CONCRETE CUBE MOULDS (150 X 150 X 150) mm
7	CONCRETE SLUMP CONE
8	COARSE AGGREGATE SIEVES & SAND SIEVER
9	SIEVES AND SIEVE SHAKER
10	AGGREGATE IMPACT TEST MACHINE
11	PHYSICAL BALANCE FOR LAB WORK
12	RAPID MOISTURE METER
13	VICAT APPARATUS WITH PLUNGERS FOR CEMENT TESTING
14	THEODOLITE ONE STAND ACCURACY
15	DUMPY LEVEL UP TO 350 MM
16	CORE CUTTER TEST APPARATUS
17	CUBE MOULDS (70MM SIZE)
18	ELECTRIC OVEN

NOTES:

1. The above list is only indicative and these IMTEs/MMEs may not be required for entire contract period and will be provided as per need. Contractor will assess actual quantity and period of requirement based on his experience.
2. Other terms and conditions regarding above items please also refer clause for T&P/MMEs.
3. All the IMTEs /MMEs required for this scope of work, except the IMTEs / MMEs provided by BHEL, are to be arranged by the contractor within the quoted rates. **The list is suggestive in nature. Any additional IMTEs / MMEs required to be arranged by the contractor.**

NOT APPLICABLE

6.0	**TIME SCHEDULE (MOBILIZATION, TIME SCHEDULE, CONTRACT PERIOD)**
6.1	**INITIAL MOBILIZATION** After receipt of LOA, Contractor shall discuss with Project Manager / Construction Manager regarding initial mobilization. Contractor shall mobilize necessary resources within 2 weeks of issue of LOA or as per the directive of Project Manager / Construction Manager. Such resources shall be progressively augmented to match the schedule of milestones as directed by BHEL Engineer.
6.2	**START DATE / ZERO DATE** The schedule date of start of work shall be the date after 2 weeks of issue of LOA; The Actual Date of Start of Contract Period (Zero Date) shall be date of handing over of site to contractor for work and shall be certified by the BHEL Engineer**.**
6.3	**COMPLETION PERIOD:** Entire work as detailed in tender specification **shall be completed within 30 (Thirty) months from the actual date of start of work** as per the programs / milestones indicated by BHEL**.** Contractor has to mobilize adequate resources to meet BHEL's commitments to their customer as indicated from time to time. **In the event the contractor fails to respond to these requirements, BHEL shall take appropriate actions to meet customer's commitments in line with the provisions of General Conditions of Contract.**
6.4	In case due to reasons not attributable to the contractor, the work gets delayed and scheduled completion gets extended, time extension will be granted by BHEL as per clause no. 2.11 of GCC.
6.5	The work under the scope of this contract is deemed to be completed in all respects, only when all the works are carried out as per satisfaction of BHEL. The decision of BHEL on completion date shall be final and binding on the contractor.
6.6	In order to meet above schedule in general, and any other intermediate targets set, to meet customer/ project schedule requirements, contractor shall arrange & augment all necessary resources from time to time on the instructions of BHEL without any extra cost to BHEL.
6.7	**CONTRACT PERIOD:** The contract period for completion of entire work under scope of this contract shall be **30 (Thirty) Months** from the actual / zero date of start of work.
6.8	**The Milestones for Electrical Bay Building for U#1 are as under:**

	Mile Stone	**Schedule**	**Intermediate Milestone (M1 & M2)**
	Completion of Raft of Electrical Bay Building	With 03 Months from Zero date	
	Completion of First Floor RCC	Within 05 Month from Zero date	
	Completion of 2nd Floor RCC	Within 7.5 Month from Zero date	
	Completion of 3rd Floor RCC	Within 10 Month from Zero date	**M1**
	Completion of 4th Floor RCC	Within 12.5 Month from Zero date	
	Completion of 5th Floor RCC	Within 15 Month from Zero date	
	Completion of 6th Floor RCC	Within 18 Month from Zero date	**M2**
	Completion of Roof RCC	Within 21 Months from Zero date	
	Completion of Brick/ Concrete Block Masonry Work including plastering	Within 23 Months from Zero Date	
	Completion of balance Finishing and Architectural Works	Within 25 Months from Zero date	
	NOTE: For Unit#2 Electrical Bay Building, above milestones will be applicable with a gap of 05 Months in completion of U#1 and U#2.		
6.9	**Provision of Penalty in case of slippage of Intermediate Milestones:** A. Two Major Intermediate Milestones are identified as M1 and M2 above. B. In case of slippage of these identified Intermediate Milestones, Delay Analysis shall be carried out on achievement of each of these two Intermediate Milestones. C. In case delay in achieving M1 Milestone is solely attributable to the contractor, 0.5% per week of executable contract value*, limited to maximum 2% of executable contract value, will be withheld. D. In case delay in achieving M2 Milestone is solely attributable to the contractor, 0.5%per week of executable contract value*, limited to maximum 3% of executable contract value , will be withheld. E. Amount already withheld, if any against slippage of M1 milestone, shall be released only if there is no delay attributable to contractor in achievement of M2 Milestone.		

	F. Amount required to be withheld on account of slippage of identified intermediate milestone(s) shall be withheld out of respective milestone payment (corresponding RA Bill) and balance amount (if any) shall be withheld @10% of RA Bill amount from subsequent RA bills. G. Final deduction towards LD (if applicable), on account of delay attributable to contractor shall be based on final delay analysis on completion/ closure of contract. Withheld amount, if any due to slippage of identified intermediate milestone(s) shall be adjusted against LD or released as the case may be. H. In case of termination of contract due to any reason attributable to contractor before completion of work, the amount already withheld against slippage of intermediate milestones shall not be released and be converted into recovery. ** Executable Contract Value - Value of work for which inputs/ fronts were* made *available to contractor and were scheduled for execution till the date of achievement of that milestone.*
6.10	**SUBMISSION OF L3 SCHEDULE** The contractor shall submit a detailed area/structure wise L3 schedule within 15 days of issue of LOA in consultation with BHEL based on the tentative schedule provided as per the clause 6.7 and 6.8 above. The detailed L3 schedule shall be approved by BHEL and same shall be implemented. Bidder shall submit L3 schedule in MS Project to meet the agreed project schedule covering various milestone activities and their split up details such as civil construction, procurement of materials, finishing activities etc. This schedule shall also clearly indicate the interface facilities/inputs to be commenced from the date of completion of the whole of the work in the package, certified by the Engineer.
6.11	**CONSEQUENCE OF DELAY** It may be noted that in the event, delay in completion is attributable to the contractor; BHEL will impose LD on the contractor as per clause no. 2.7.9 of GCC.

7.0	**TERMS OF PAYMENT**
7.1	The 'Engineer' will certify regarding the actual work executed in the measurement books and bills, which shall be accepted by the contractor in measurement book.
7.2	**The Contractor shall be paid monthly running bill as per chapter – X of SCC and Clause Nos. 2.22 & 2.23 of GCC.** The format for billing shall be approved by BHEL before raising invoices.
7.3	The contractor on certification of the engineer at site is entitled for payments of his running bills which shall be subject to any deduction/retention specifically under clauses 2.22 of GCC and 10.0 of SCC.
7.4	BHEL will release the payment through Electronic Fund Transfer (EFT)/RTGS
7.5	Final bill shall be submitted after completion of works and upon material reconciliation along with all prescribed formats.

8.0	**TAXES & DUTIES**
8.1	The contractor shall pay all (save the specific exclusions as enumerated in this clause) taxes, fees, license, charges, deposits, duties, tools, royalty, commissions, other charges, etc. which may be levied on the input goods & services consumed and output goods & services delivered in course of his operations in executing the contract. In case BHEL is forced to pay any of such taxes/duties, BHEL shall have the right to recover the same from his bills or otherwise as deemed fit. However, provisions regarding **GST** on output supply (goods/service) and TDS/TCS as per Income Tax Act shall be as per following clauses.
8.2	**GST (Goods and Services Tax)**
8.2.1	GST as applicable on output supply (goods/services) are excluded from contractor's scope; therefore, contractor's price/rates shall be **exclusive** of GST. Reimbursement of GST is subject to compliance of following terms and conditions. BHEL shall have the right to deny payment of GST and to recover any loss to BHEL on account of tax, interest, penalty etc. for non-compliance of any of the following condition.
8.2.2	The admissibility of GST, taxes and duties referred in this chapter or elsewhere in the contract shall be limited to direct transactions between BHEL & its Contractor. BHEL shall not consider GST on any transaction other than the direct transaction between BHEL & its Contractor.
8.2.3	Contractor shall obtain prior written consent of BHEL before billing the amount towards such taxes. Where the GST laws permit more than one option or methodology for discharging the liability of tax/levy/duty, BHEL shall have the right to adopt the appropriate one considering the amount of tax liability on BHEL/Client as well as procedural simplicity with regard to assessment of the liability. The option chosen by BHEL shall be binding on the Contractor for discharging the obligation of BHEL in respect of the tax liability to the Contractor.
8.2.4	Contractor has to submit GST registration certificate of the concerned state. Contractor also needs to ensure that the submitted GST registration certificate should be in active status during the entire contract period.
8.2.5	Contractor/Vendor has to issue invoice indicating HSN/SAC code, Description, Value, Rate, applicable tax and other particulars in compliance with the provisions of relevant GST Act and Rules made thereunder.

8.2.6	Vendor has to submit GST compliant invoice within seven days from the due date of invoice as per GST Law. In case of delay, BHEL reserves the right of denial of GST payment if there occurs any hardship to BHEL in claiming the input thereof. In case of goods, vendor has to provide scan copy of invoice & GR/LR/RR to BHEL before movement of goods starts. Special care should be taken in case of month end transactions.
8.2.7	Vendor has to ensure that invoice in respect of such services which have been provided/completed on or before end of the month should not bear the date later than last working day of the month in which services are performed.
8.2.8	Subject to other provisions of the contract, GST amount claimed in the invoice shall be released on fulfilment of all the following conditions by the Contractor: - a. Supply of goods and/or services have been received by BHEL. b. Original Tax Invoice has been submitted to BHEL. c. Contractor/ Vendor has submitted all the documents required for processing of bill as per contract/ purchase order/ work order. d. In cases where e-invoicing provision is applicable, vendor/contractor is required to submit invoice in compliance with e-invoicing provisions of GST Act and Rules made thereunder. e. Contractor has filed all the relevant GST return (e.g. GSTR-1, GSTR-3B, etc.) pertaining to the invoice submitted and submit the proof of such return along with immediate subsequent invoice. In case of final invoice/ bill, contractor has to submit proof of such return within fifteen days from the due date of relevant return. f. Respective invoice has appeared in BHEL's GSTR - 2A for the month corresponding to the month of invoice. Alternatively, BG of appropriate value may be furnished which shall be valid at least one month beyond the due date of confirmation of relevant payment of GST on GSTN portal or sufficient security is available to adjust the financial impact in case of any default by the contractor. g. Contractor has to submit an undertaking confirming the payment of all due GST in respect of invoices pertaining to BHEL.
8.2.9	Any financial loss arises to BHEL on account of failure or delay in submission of any document as per contract/purchase order/work order at the time of submission of Tax invoice to BHEL, shall be deducted from contractor's bill or otherwise as deemed fit.

8.2.10	TDS as applicable under GST law shall be deducted from contractor's bill.
8.2.11	Contractor shall comply with the provisions of e-way bill wherever applicable. Further wherever provisions of GST Act permits, all the e-way bills , road permits etc. required for transportation of goods needs to be arranged by the contractor.
8.2.12	Contractor shall be solely responsible for discharging his GST liability according to the provisions of GST Law and BHEL will not entertain any claim of GST/interest/penalty or any other liability on account of failure of contractor in complying the provisions of GST Law or discharging the GST liability in a manner laid down thereunder.
8.2.13	In case declaration of any invoice is delayed by the vendor in his GST return or any invoice is subsequently amended/altered/deleted on GSTN portal which results in any adverse financial implication on BHEL, the financial impact thereof including interest/penalty shall be recovered from the Contactor's due payment.
8.2.14	Any denial of input credit to BHEL or arising of any tax liability on BHEL due to non-compliance of GST Law by the Contractor in any manner, will be recovered along with liability on account of interest and penalty (if any) from the payments due to the Contactor.
8.2.15	In the event of any ambiguity in GST law with respect to availability of input credit of GST charged on the invoice raised by the contractor or with respect to any other matter having impact on BHEL, BHEL's decision shall be final and binding on the contractor.
8.2.16	**Variation in Taxes & Duties:** Any upward variation in GST shall be considered for reimbursement provided supply of goods and services are made within schedule date stipulated in the contract or approved extended schedule for the reason solely attributable to BHEL. However downward variation shall be subject to adjustment as per actual GST applicability. In case the Government imposes any new levy/tax on the output service/goods after price bid opening, the same shall be reimbursed by BHEL at actual. The reimbursement under this clause is restricted to the direct transaction between BHEL and its contactor only and within the contractual delivery period only.

	In case any new tax/levy/duty etc. becomes applicable after the date of Bidder's offer but before opening of the price Bid, the Bidder/Contractor must convey its impact on his price duly substantiated by documentary evidence in support of the same before opening of price bid. Claim for any such impact after opening the price bid will not be considered by BHEL for reimbursement of tax or reassessment of offer.
8.3	**Income Tax:** **TDS/TCS** as applicable under Income Tax Act, 1961 or rules made thereunder shall be deducted/collected from contractor's bill.

8.4	**BUILDING & OTHER CONSTRUCTION WORKERS (REGULATION OF EMPLOYMENT AND CONDITIONS OF SERVICE) ACT, 1996 (BOCW ACT) AND RULES OF 1998 READ WITH BUILDING & OTHER CONSTRUCTION WORKERS CESS Act, 1996 & CESS RULES, 1998.**
	In case any portion of work involves execution through building or construction workers, then compliance to the above titled Acts shall be ensured by the contractor and contractor shall obtain license and deposit the cess under the Act. In the circumstances it may be ensured as under:-
8.4.1	It shall be the sole responsibility of the contractor in the capacity of employer to forthwith (within a period of 15 days from the award of work) apply for a license to the Competent Authority under the BOCW Act and obtain proper certificate thereof by specifying the scope of its work. It shall also be responsibility of the contractor to furnish a copy of such certificate of license / permission to BHEL within a period of one month from the date of award of contract.
8.4.2	It shall be the sole responsibility of the contractor as employer to ensure compliance of all the statutory obligations under these act and rules including that of payment / deposit of 1% cess on gross payment made for value of work involving building or construction workers engaged by the contractor within a period of one month from the receipt of payment.
8.4.3	It shall be the responsibility of the sub-contractor to furnish the receipts /challans towards deposit of the cess together with the number, name and other details of beneficiaries (building workers) engaged by the sub-contractor during the preceding month.
8.4.4	It shall be the absolute responsibility of the sub-contractor to make payment of all statutory payments & compensations to its workers including that is provided under the Workmen's Compensation Act, 1923.
8.4.5	The contractor shall, however ensure before deposit of any BOCW Cess, that customer is not depositing the same in order to avoid excess deposit of cess.
8.4.6	The contractor shall bear cost of BOCW cess either by way of deposit or through recovery by BHEL in case the same is deposited by the customer.
8.4.7	In case of failure in above mentioned compliances, BOCW Cess @ 1% as well as applicable penalty as specified in BOCW Act/Rules shall be deducted from the contractor.

NOTE:

1	The Gross amount is to be construed as cost of construction in line with the provisions of the BOCW of the BOCW Cess act and in case of compliance by customer by way of deduction at source in line with clause No 3(2) of the act an equitable adjustment to the relatable cost of construction attributable to the bidder shall be

	made in terms of clause no 8.2 of TCC
2	In case compliance by customer by way of deduction at source in line with clause no 3(2) is not resorted to, the compliance of BOCW Cess act shall be ensured by the bidder in line with the provisions of BOCW Cess act in terms of clause no 8.2.2b of TCC
3	The bidder may consider the cost of construction for levy of BOCW Cess inclusive of GST, however, due to whatsoever reason if the GST does not form the cost of construction for levy of aforesaid Cess an equitable adjustment thereof shall be made to the contract price.

9.0	**MATERIALS**
9.1	The contractor shall at his own expenses provide all materials including paints, welding electrodes etc. required for the work. However for permanent works **cement, ready mix concrete, reinforcement steel and couplers will be issued free of cost** from BHEL / Customer stores or at a point instructed by BHEL as per terms & conditions specified in clause No. 9.14.
9.2	All materials to be provided by the Contractor shall be of the best kind in conformity with the specifications laid down in the contract or as per relevant Indian standard and the Contractor shall, if requested by the BHEL Engineer, furnish proof to the satisfaction of BHEL Engineer that the materials so comply.
9.3	The Contractor shall, at his own expense and without delay, supply to the BHEL Engineer, samples of materials proposed to be used in the works. The BHEL Engineer shall within seven days of supply of samples or within such further period as he may require will intimate to the Contractor in writing, whether samples are approved by him or not. If samples are not approved, the Contractor shall forthwith arrange to supply to the BHEL Engineer for his approval fresh samples complying with the specifications laid down in the Contract. Any delay in approval of samples (original or fresh ones) shall not make the contractor eligible for any compensation.
9.4	The BHEL Engineer shall have full powers for removal of any or all of the materials brought to site by the Contractor which are not in accordance with the Contract specifications or do not conform in character or quality to samples approved by him. In case of default on the part of the Contractor in removing rejected materials, the BHEL Engineer shall be at liberty to have them removed by other means. The BHEL Engineer shall have full powers to procure other proper material to be substituted for rejected materials and in the event of the Contractor refusing to comply; he may cause the same to be supplied by other means. All costs, which may attend upon such removal and / or substitution, shall be borne by the Contractor.
9.5	The Contractor shall indemnify BHEL, its representatives or employees against any action, claim or proceeding relating to infringement or use of any patent or design or any alleged patent or design rights and shall pay any royalties or other charges which may be payable in respect of any article or material or part thereof included in the Contract. In the event of any claim being made or action being brought against BHEL or any agent, servant or employee of BHEL in respect of any such matters as aforesaid, the Contractor shall immediately be notified thereof, provided that such indemnity shall not apply when such infringement has taken place in complying with

	the specific directions issued by BHEL but the Contractor shall pay any royalties or other charges payable in respect of any such use, the amount so paid being reimbursed to the Contractor only if the use was the result of any drawings / specifications issued after submission of the tender.
9.6	The BHEL Engineer shall be entitled to have tests carried out as specified in the Contract for any materials supplied by the Contractor other than those for which, as stated above, satisfactory proof has already been furnished, at the cost of the Contractor and the Contractor shall provide at his expense all facilities which the Engineer may require for the purpose. If no tests are specified in the Contract, and such tests are required by the Engineer, the Contractor shall provide all facilities required for the purpose and the charges for these tests shall be borne by the Contractor only. The cost of materials consumed in tests shall be borne by the Contractor in all cases except when otherwise provided.
9.7	In addition, the Contractor shall perform / submit at his own cost such tests / samples as may be required by the BHEL Engineer out of the materials used by the company except for the costs of materials used in such tests/ samples.
9.8	After acceptance of the Contract, if Contractor desires BHEL to supply any other materials, such material may be supplied by BHEL, if available, at rates to be fixed by the BHEL Engineer along with prevailing departmental charges. BHEL reserve the right not to issue any material. The non-issue of such material will not entitle the Contractor for any compensation whatsoever either in time or in cost.
9.9	Material required for the works, whether brought by the Contractor or supplied by BHEL, shall be stored by the Contractor only at places approved by the Engineer. Storage and safe custody of material shall be the responsibility of the contractor.
9.10	BHEL's officials concerned with the Contract shall be entitled at any time to inspect and examine any materials intended to be used in or on the works, either on the Site or at factory or workshop or other place(s) where such materials are assembled, fabricated, manufactured or at any place (s) where these are lying or from which these are being obtained and the Contractor shall give such facilities as may be required for such inspection and examination.
9.11	All materials brought to the Site shall become and remain the property of BHEL and shall not be removed off the Site without the prior written approval of the BHEL Engineer. But whenever the Works are finally completed and advance, if any, in respect of any such material is fully recovered, the Contractor shall at his own expense forthwith remove from the Site all surplus material originally supplied by him

	and upon such removal, the same shall re-vest in and become the property of the Contractor.
9.12	It shall be the responsibility of the contractor to obtain prior approval of BHEL, regarding suppliers, type of electrodes etc. before procurement of welding electrodes / TIG wires. On receipt of electrodes at site these shall be subjected to inspection and approval by BHEL. The contractor shall inform BHEL details regarding type of electrodes, batch No. date of expiry etc. and produce test certificate for each lot / batch with correlation of batch / lot no. with respective test certificate. No electrode will be allowed to be used without valid test certificate.
9.13	All charges on account of Octroi, terminal or sales tax and other duties on material obtained for the works from any source shall be borne by the contractor.
9.14	**ISSUE AND ACCOUNTING OF CEMENT, RMC AND REINFORCEMENT STEEL.**
9.14.1	**Cement, Ready Mix Concrete, Reinforcement steel and Couplers will be issued as free issue materials from BHEL site stores or other issuing points as specified by the Engineer.** Such issues would be only for permanent works. Preparing, Batch Mixing, Conveying and Placement/Pouring of Concrete in structure is in the scope of RMC supplier. However for any unforeseen conditions, bidder may maintain the suitable facility for taking the RMC from installed batching plant and further pouring in structure. Necessary indents shall be raised by the contractor as per procedure laid down by the Engineer-in-Charge in advance of the actual requirement for incorporation in the works.
9.14.2	Materials will be issued only for permanent works and not for making templates, other temporary works, enabling works etc. and the same shall not be taken into account for purpose of material reconciliation. **Quarterly requirement of steel including reinforcement couplers** must be positively submitted by the contractor at the last month of the previous quarter. The contractor shall submit to the engineer, a statement indicating estimated quantity of **cement & RMC required at least three months in advance.** In addition, the contractor shall also furnish the estimated requirement of Cement, RMC and steel during a month by the third week of the previous month indicating his requirement.
9.14.3	The contractor shall bear all other costs including the lifting, carting from issue points to works site / contractor's stores, custody and handling etc. and return of surplus /

	serviceable materials to Owner's stores to be designated by the Engineer-in- charge and all expenditure will be made by the contractor.
9.14.4	All steel shall be issued in available lengths / shapes and no claims for extra payment on account of issue of non-standard lengths / shapes will be entertained. For the purpose of billing and accounting only linear measurement will be taken and weight will be calculated as per the IS Co-efficient. The different in unit weight as per IS and actual as issued, if any shall be to the contractor's account and contractor shall quote the rates for corresponding item to take care of such difference.
9.14.5	Cement, as received from the Manufacturer / Stockiest will be issued to the contractor. The theoretical weight of each bag of cement for issue purpose will be considered as 50Kgs. Per Bag. Any type of cement and in any container as received from Manufacturer / Stockiest shall be issued to the contractor No claim whatsoever shall be entertained on this. Cement bags weighing up to 4% less will be accepted by the contractor and accounted for as 50Kg per bag.
9.14.6	For ready mix concrete, contractor shall receive RMC at the point of pouring or nearest feasible location at site. Quantity received by the contractor shall be certified as per Batch Reports / weighment slips and same shall be received, signed and stamped by the contractor and submitted to BHEL Engineer as a proof for receiving of requisite quantity of concrete.
9.14.7	Providing Ready Mix Concrete up to the point of pouring in acceptable quality as per BHEL's / Customer's requirement is the prime responsibility of the RMC agency. However, Contractor may depute his engineer at the RMC agency's batching plant to ensure the quality/ quantity of concrete being produced and any doubt should be brought in the notice of BHEL's Quality-in-charge, whose decision in this regard shall be final and binding on the contractor. Acceptance / Rejection of freshly produced concrete will be the sole right of BHEL/it's Customer.
9.14.8	Contractor shall take over the RMC at the earliest as and when brought to the point of pouring at site or at any other location suitable to him and should make all arrangement to pour the concrete within the time limit as permitted under technical specifications/ approved quality procedures at site. Any loss/rejection of concrete due to delay in pouring resulting from the contractor's unpreparedness or any other reason attributable to contractor will be to the contractor's account. Such concrete will be accounted for the quantity of concrete issued to the contractor and penal recoveries for excess consumption/ wastage of concrete (if any) beyond the permissible limit will be made as mentioned under the clause no. 91.14.17 below.

9.14.9	Any rejection of the concrete/structure by BHEL/Customer due to poor workmanship of the contractor, i.e. honeycombing, improper finish, wrong alignment/position or any other reason whatsoever except the quality of concrete (as tested and certified by BHEL/Customer at quality lab) will be on the account of contractor. In case such defects are found same shall be rectified/ corrected by the contractor in the manner as acceptable to BHEL/Customer or if required, contractor shall dismantle and re-construct the same as per the approved procedure at his own cost. Consumption of RMC, Steel or any other free issue material from BHEL for such works will be recovered from the contractor at the penal rates.
9.14.10	The Contractor shall maintain good stores for storing the cement issued to him. The flooring of the storage house, the clearance of cement bags from the side walls etc., shall be as per the instructions of the Engineer-in-charge.
9.14.11	The cement stores shall be open for supervision and verification by the Engineer-In-Charge or his authorized representative by any time when the Engineer-In-Charge feels the need to do so.
9.14.12	In the case of steel materials, the same shall be issued generally on the basis of linear measurement and the corresponding weight will be calculated as per Indian Standard. For the purpose of billing & accounting, only linear measurement will be taken and any difference in weight based on linear measurement & actual weight shall be to contractor's account. Quoted price shall be deemed to include the above & the permissible wastage mentioned. No claim whatsoever shall be entertained on account of wastage & difference in weight as referred to above.
9.14.13	Issue of stores material is subject to availability and the contractor shall not be entitled to any claim or compensation for non-supply or delay in the supply under any circumstances. The material will be issued generally during the working hours.
9.14.14	The theoretical consumption of cement shall be based on the following: a. For design mix concrete as per approved design mix. b. For nominal mix concrete work, as per minimum cement as specified or as approved by engineer-in-charge. c. For item of works, where volume mix is permitted in writing by the BHEL, for masonry works, plaster and other miscellaneous items, the cement consumption shall be governed by the "Statement of cement consumption" attached to the latest version of Delhi Schedule of Rates (DSR) unless otherwise specified in the specifications or the drawing of contract or mutually agreed by engineer-in-charge and the contractor.

	If the co-efficient for consumption of cement as per the exact BOQ item is not available in DSR, same shall be derived on proportionate basis from co-efficient of similar DSR Item. d. Actual consumption = Issue – Surplus/ unused quantity of cement returned in good condition by the contractor to store. (No sweep cement will be taken back by BHEL). The theoretical consumption of cement thus worked out shall be binding upon the Contractor for reconciliation of Cement issued by BHEL. For any excess /under consumption based on these coefficients, the Contractor shall be penalized as per contract provisions. Though, permissible wastage specified shall be considered, while effecting penal recovery, no other allowance whatsoever shall be taken for reconciliation purposes.
9.14.15	The theoretical consumption of reinforcement steel, couplers and ready mix concrete required for the work will be calculated on the basis of approved drawings, Bar Bending Schedule / Joint Measurements. In the case of cement, the theoretical consumption shall be decided by the Engineer as mentioned above and his decision in this regard shall be final and binding on the Contractor. Ready Mix Concrete shall be measured on the basis of approved drawings and joint measurements by the BHEL Engineer and his decision in this regard shall be final and binding on the contractor. Reinforcement steel shall be measured by weight in tones. The weight will be arrived at by multiplying the used length by the sectional weight. The sectional weight will be same as were applied at the time of issue. Standard hooks, cranks, bends and authorized laps, chairs, separator pieces etc. specified in drawing or instructed by engineer as required shall be measured and paid for. No payment shall be made for binding wires, spacer block etc. required for keeping the steel in position unless otherwise specified in the contract. No extra payment will be made for modification of already embedded reinforcement, if required due to faulty fabrication or placement.
9.14.16	The contractor shall submit proper account of material / material reconciliation statement for the material drawn by him from stores once in every three months. Failing compliance of this requirement further issue of steel to the contractor may be suspended and no claim of compensation for delay in execution on this account shall be entertained.
9.14.17	All the cement, ready mix concrete, reinforcement steel and reinforcement couplers thus issued shall be properly accounted for as per the following permissible wastage over the theoretical quantity / consumption incorporated in the works.

	Item	**Area**	**Permissible Variation / Wastage**
	Cement and Ready Mix Concrete	For All works	1.5%
	Reinforcement Bars & MS Earthing Rods	For All works	3%
	Reinforcement Couplers	For All works	3%
9.14.18	Any unused / serviceable quantity of cement, reinforcement steel & ready mix concrete not returned in good condition & wastages / loss / consumption beyond specified / agreed limits shall be charged at penal rate of **Rs 7000 per MT for cement, Rs 80,000 per MT for reinforcement steel, Rs. 8000 per CuM for Ready Mix Concrete & Rs. 250 per coupler** at the time of preparing final bill, during finalization of the contract. The decision of Engineer-in-charge with regard to applicability of penal rates shall be final & binding upon the contractor.		
9.14.19	For the materials i.e. Reinforcement (TMT) and Reinforcement Couplers being issued free of cost, the scrap generated shall belong to BHEL.		
9.14.20	Empty cement bags shall be the property of contractor and recovery @ 01/- (Rs. One only) per empty cement bag shall be made from their RA bills.		
9.14.21	**SCRAP & SERVICEABLE MATERIALS:** All reinforcement steel of length above 3 M shall be considered as serviceable materials provided the materials is in good and acceptable condition. Reinforcement steel in length less than 3 M shall be treated as scrap.		
9.14.22	For other conditions regarding Material Handling, Storage, Preservation, Issue and Accounting please refer SCC Chapter-VI.		

10.1	**EXECUTION OF WORK**
10.1.1	The work shall be executed in a workman like manner and to the entire satisfaction of the Engineer and as per technical specification issued with tender, IS codes, technical specifications as applicable. In case of conflict, the decision of the Engineer I/c shall be final & binding.
10.1.2	The Engineer I/c will communicate or confirm his instructions to the Contractor in respect of the execution of the work in a "Work Site Order Book" maintained at his office and the Contractor shall visit this office daily and shall confirm receipt of such instructions by signing the relevant entries in this book or through e-mail. Such entries / e-mails will rank as order or notices in writing within the intent and meaning of these conditions.
10.1.3	Only BHEL approved make of electrodes will be used. All electrodes shall be heated and dried in the electric electrode drying oven to the required temperature for the period specified by the Engineer before these are used in erection work. All welders shall have electrodes drying portable oven at the work spot. The electrodes brought to site will have valid manufacturing test certificate. The test certificate will have co-relation with the lot no. / batch no. given on electrode packets. No electrodes will be allowed to be used in the absence of above requirement. The thermostat and thermometer of electrode drying oven will be also calibrated and test certificate from Govt. approved / accredited test house traceable to National / International standards) will be submitted to BHEL before putting the oven in use. Periodical calibration for the same shall also be arranged by the contractor within the finally accepted rates.
10.2	**SETTING OUT**
10.2.1	All the works shall be set out to the true lines, grades and elevation indicated on the drawing. The contractor shall be responsible to locate and set out the works. Only one grid reference line and bench mark all be made available for setting out the works under the contract. This reference lines shall be used as datum for the works under the contract and the contractor has to establish for his work area at available points horizontal and vertical control points. The contractor shall inform BHEL well in advance of the times & places at which he wishes to do work in the area allotted to him so that suitable datum points established by him are checked by BHEL / Customer to enable the contractor to proceed with the works. Any work done without being properly located may be removed and / or dismantled by BHEL / Customer at contractor's expense.

10.2.2	The contractor shall at his own expense take all proper and responsible precautions to preserve and maintain these datum marks to its true position. In the event of these marks being disturbed or obliterated by accident or due to any other cause whatsoever, the same may be deemed necessary, placed by BHEL / Customer at contractor's expenses.
10.3	**SITE DRAINAGE**
10.3.1	All water including sub-soil water which may accumulate on the Site during the progress of the works or in trenches and excavations, including monsoon period shall be removed by the contractor from the Site to the satisfaction of the Engineer. It will also be responsibility of the contractor to de-water all the foundation pits, trenches with suitable de-watering methods like, pumping out, well point system etc. considering the depth of water table at plant site. All such expenditure on de-watering shall be deemed to be included in quoted rates.
10.4	**INSPECTION AND STAGE APPROVAL OF THE WORK**
10.4.1	The owner or his duly authorized representative shall have at all reasonable times access to the contractor's premises or works and shall have the power to inspect drawings or any portion of the work, examine the materials and workmanship and shall have the authority to reject any work. This would be implemented through joint inspection by the representative of the owner and BHEL and in the form of joint protocols without any extra claims and loss of time and amount.
10.4.2	All work embracing more than one process shall be subject to examination and approval at each stage thereof and the Contractor shall give due notice in writing to the Engineer when each stage is ready. In default of such notice being received, the Engineer shall be entitled to approve the quality and extent thereof at any time he may choose and in the event of any dispute, the decision of the Engineer thereon shall be final and conclusive.
10.5	**UNCOVERING AND MAKING GOOD**
10.5.1	The Contractor shall uncover any part of the Works and/or make openings in or through the same as the Engineer may from time to time direct for his verification and shall reinstate and make good such part to the satisfaction of the Engineer. If any such part has been covered up or put out of view after being approved by the Engineer and is subsequently found on uncovering to be executed in accordance with the Contract, the expenses of uncovering and

	/ or making opening in or through, reinstating and making good the same shall be borne by BHEL. In any other case all such expenses shall be borne by the Contractor.
10.6	**DISCREPANCIES AND ADJUSTMENT OF ERRORS**
10.6.1	The several documents forming the Contract are to be taken as mutually explanatory of one another, detailed drawings being followed in preference to small-scale drawings and figures dimensions in preference to scale and special conditions in preference to general conditions.
10.6.2	In case of discrepancies between schedules of quantities, the specification and / or the drawings, the following order of preference shall be observed. (a) Description in schedule of quantities. (b) Technical Conditions of Contract. (c) Drawings. (d) Technical Specifications (e) Special Conditions of Contract (f) General conditions of contract
10.6.3	If there are varying or conflicting provisions made in any one document forming part of the contract, the Engineer shall be the deciding authority with regard to the document.
10.6.4	Any error in description, quantity in schedule of quantities or any omission there from shall not vitiate the contract or release the contractor from the execution of the whole or any part of the works comprised therein according to the drawings and specifications or from any of his obligations under the contract.
10.7	**MATERIAL OBTAINED FROM EXCAVATION**
10.7.1	Valuable Materials / Archeologically important materials of any kind obtained from excavation on the Site shall remain the property of BHEL / its client and shall be disposed of as the Engineer may direct, at no extra cost.
10.8	**SAFETY CODE**

10.8.0	**The contractor shall comply with following towards Safety and Social Accountability.**
10.8.1	Besides provision with regard to SAFETY under Clause 9.0 of SCC, the contractor will be responsible for Health, Safety & Environment management at site for the construction activities to be carried out by them. The contractor shall continuously take special care to ensure the safety and prevention of human and equipment accidents and maintain good sanitary conditions in and around the site. All the construction work and plant operation must be carried out in the safest possible manner. The Engineer reserves the right to stop any process which, in the Engineer's opinion, is being performed dangerously. In this case the contractor must immediately adhere the requisite safety precautions and any delays attributed to the work stoppage on this account shall not affect the agreed contractual finishing dates.
10.8.2	HSE plan for site operation by Sub Contractor (Doc No. HSEP 14 Rev 00 attached) shall be followed.
10.9	**NUISANCE**
10.9.1	The Contractor shall not at any time do, cause or permit any NUISANCE on Site or do anything which shall cause unnecessary disturbance or inconvenience to owners, tenants or occupiers of other properties near the Site and to the public generally.
10.10	**TREASURE , TROVE , FOSSILS etc.**
10.10.1	All fossils, coins, articles of value or antiquity and structures and other remains or things of geological or archaeological interest discovered on the site shall be the absolute property of BHEL / BHEL's client and the Contractor shall take reasonable precautions to prevent his workmen or any other person from removing or damaging any such article or thing, shall immediately upon discovery thereof and before removal, acquaint the Engineer with such discovery and carryout the Engineer's directions as to the disposal of the same.
10.11	**PROTECTION OF WORKS**
10.11.1	Trees designated by the Engineer shall be protected from damage during the course of the Works and earth level within 1 meter of each such tree shall not be charged. Where necessary, such trees shall be protected by providing temporary fencing.
10.11.2	The contractor shall provide and maintain at his own expense all lights, guards, fencing and watching when and where necessary or required by the

	Engineer for the protection of the Works or for the safety and convenience of those employed on the Works or the public.
10.11.3	The contractor shall have total responsibility for protecting his works till it is finally taken over by the Engineer. No claim will be entertained by the Engineer for any damage or loss to the contractor's works and the contractor shall be responsible for the complete restoration of the damaged works to its original condition to comply with the specifications and drawings. Should any such damage to the contractor's works occur because of other party not under his supervision or control, the contractor shall make his claim directly with the party concerned. The contractor shall not cause any delay in the repair of such damaged works because of any delay in the resolution of such disputes. The contractor shall proceed to repair the work immediately and no cause thereof will be assigned pending resolution of such disputes.
10.12	**RECORD FOR MATERIALS CONSUMED**
10.12.1	The contractor shall maintain and furnish to the Engineer the RECORD OF MATERIALS consumed in the works for each activity. The statement showing the theoretical vis-à-vis actual consumption of specified materials, such as structural /reinforcement steel, couplers, cement, RMC, bitumen, lead, paint etc., shall be enclosed along with the running bills submitted by the contractor. Contractor has to also furnish the test results of the materials used in the work as per IS specifications.
10.13	**PROTECTION OF EMBEDMENTS, BOLTS ETC.**
10.13.1	The contractor shall ensure proper protection to the satisfaction of the Engineer, of all bolts, inserts, embedment etc. from weather etc. / by greasing, rapping them with gunny bags or canvas or by any other means as directed by Engineer. Cost of such protections shall be deemed to be included in the rates quoted for the item.
10.14	**COMPLETION OF WORK AND COMMENCEMENT OF GURANNTEE PERIOD**
10.14.1	The works shall be completed to the entire satisfaction of the Engineer and in accordance with the completion schedule as specified in the Contract, and all unused stores and materials, tools, plant, equipment, temporary buildings, site office, labor hutments and other things shall be removed and the site and work cleared of rubbish and all waste materials and delivered up clean and tidy to the satisfaction of the Engineer at the Contractor's expenses.

10.14.2	BHEL shall have power to take over from the Contractor from time to time such sections of the work as have been completed to the satisfaction of the Engineer. Such work however shall not be treated as have been completed until the extra / pending works are executed to the satisfaction of Engineer.
10.14.3	The Engineer shall certify to the contractor the date on which the work is completed and the date thereof for commencement of Guarantee Period. Guarantee Period shall be as given in GCC.
10.15	**CLEARANCE OF SITE AND REPAIRS.**
10.15.1	Contractor has to clear the site / area where mechanical and electrical erection work is to be commenced / or in progress. The contractor shall remove construction materials and equipment lying in the vicinity and causing obstruction in the erection work within 24 hrs Notice. In case, he fails to clear the site, this will be done at his risk & cost by BHEL.
10.16	**QUALITY ASSURANCE**
10.16.1	The contractor has to establish / arrange at site the field testing facilities for testing of civil construction materials and concrete cubes for ensuring the proper quality, grade and strength of the materials used in the construction in line with approved field quality check list of BHEL/ its client. Contractor has to submit detailed report for testing of all material used etc. All testing shall be done as per IS code specifications/ BHEL's quality plan. If further test is required by the engineer to be carried from outside laboratory, the cost of the same shall be borne by the contractor. It is the responsibility of the contractor to ensure compliance with the quality assurance requirement stipulated in the tender document /during execution of contract. For this purpose contractor shall have appropriate quality assurance organization and have personnel with requisite qualification to carry out inspection /quality surveillance for the entire work carried out at site.
10.16.2	**Quality Assurance Program**
10.16.2.1	The equipment and services under the scope of this Contract whether manufactured or performed within the Contractor's Facilities or at his Sub-contractor's premises or at the project site or at any other place of work shall be subjected to quality surveillance commensurate with customer's QA programme to control such activities at all stages necessary, and inspection by the Customer's authorised Quality Surveillance Engineer.
10.16.2.2	**Quality Management System of Contractor:** In order to provide assurance to the Customer (NPCIL), the contractor shall, based on the NPCIL's QA

	Programme, prepare a QA manual, which shall be finally accepted by the BHEL/Customer after discussions before commencement of work. The Quality Management System of the contractor shall generally cover, but not limited to the following:
a.	His organization structure for the management and implementation of the proposed quality management system including interfaces.
b.	Design capabilities & control.
c.	Documentation control system.
d.	Qualification data for Contractor's key personnel.
e.	The procedure for purchase or materials, parts, components and selection of Sub-contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of materials purchased etc.
f.	Traceability of material used in production.
g.	System for shop manufacturing, construction/fabrication and site erection controls through QA plans.
h.	Control of non-conforming items and system for corrective and preventive actions, including disposal of non-conforming items.
i.	Inspection and test procedures both for manufacture and field activities (construction and erection).
j.	Control of calibration and testing of inspection, measuring and testing equipment.
k.	System of indication and appraisal of inspection status.
l.	System of quality audits.
m.	Training, certification and authorization of personnel.
n.	System for authorizing release of manufactured product to the customer.
o.	System of intimation by the System for maintenance of records.
p.	System for handling, storage, preservation and delivery of items.
10.16.2.3	In addition, the contractor shall establish a quality plan detailing out the specific quality control procedure to be adopted for controlling the quality characteristics relevant to each item of equipment/facilities which are to be supplied and erected as per the contract, in consultation with the Engineer-in-charge and have it approved by him before start of the work. The contractor shall also submit a list of all key persons to be engaged in the contract, along with their qualification, experience, organizational position etc.
10.16.2.4	The Contractor shall be required to submit the relevant Quality Assurance document within three weeks of completion, which shall include relevant test reports connected with all engineering controls adopted by him during manufacture/construction. The Customer's duly authorized representative

	reserves the right to carry out Quality Audit and Quality Surveillance of the systems and procedures of the Quality Management and Control Activities of the Contractor/ his vender.
10.16.3	**Inspection, Testing and Rejection** The BHEL's/Customer's Engineer-in-Charge, his duly authorised representative and/or an outside inspection agency acting on behalf of the BHEL/Customer shall have at all reasonable times access to the Contractor's premises or facilities and shall have the power at all reasonable times to inspect and examine the materials and workmanship during manufacture or erection and if part of the Stores is being manufactured or assembled at other premises or works, the Contractor shall obtain for the BHEL/ Customer and for his duly authorised representative permission to inspect as if the Stores were manufactured or assembled on the Contractor's own premises.
10.16.3.1	The Contractor shall give the BHEL's/Customer's Personnel full opportunity to carry out these activities, including providing access, facilities, permissions and safety equipment. No such activity shall relieve the Contractor from any obligation or responsibility.
10.16.3.2	The Plant and Equipment / Facilities (in part or full) shall be offered by the Contractor for inspection at place of manufacture and/or on the site or at such places as may be specified by the Inspector at the Contractor's risk, expense and cost. The Contractor shall give notice of readiness of Stores/ facilities for inspection to the Inspector and shall perform all tests and inspection in presence of the Inspector as per the terms of the tender specifications and approved inspection plan. In default of such notice, the BHEL/Customer shall be entitled to appraise the quality and extent thereof.
10.16.3.3	Test Certificates and Guarantee Certificates if required by the Inspector shall be obtained and furnished to him free of cost by the Contractor and/or from the specified agency.
10.16.3.4	The Contractor shall promptly forward to the BHEL / Customer duly certified reports of the tests. When the specified tests have been passed, BHEL/ Customer (NPCIL) shall endorse the Contractor's test certificate, or issue a certificate to him, to that effect.
10.16.3.5	Where consignments are required to be delivered / dispatched after inspection by the Inspector as per the Contract, a "Shipping Release" issued by the Inspector shall be enclosed along with the delivery challan or other shipping documents viz. (Lorry Receipt, Railway Receipt) accompanying the consignments.
10.16.3.6	The Contractor agrees that neither the execution of a test and/or inspection of Plant and Equipment or any part of the Facilities, nor the attendance by the BHEL/Customer or the Engineer-in-charge, nor the issue of any test

	certificate, shall release the Contractor from any other responsibilities under the Contract.
10.16.3.7	Except as otherwise specified in the Contract, the Contractor shall provide all apparatus, assistance, documents and other information, electricity, equipment, fuel, consumables, instruments, labour, materials, and suitably qualified and experienced staff, as are necessary to carry out the specified tests efficiently. The Contractor shall agree, with the BHEL the time and place for the specified testing of any Plant, Materials and other parts of the Facilities.
10.16.3.8	No part of the facilities shall be covered up or put out of view without the approval of the Engineer-In-Charge or his authorised representative and the Contractor shall afford full opportunity for examination and measurement of any part of the facilities which is about to be covered up or put out of view and for examination of foundations before permanent work is placed thereon.
10.16.3.9	The Contractor shall give due notice to the Engineer-In-Charge or his authorised representative whenever any such part of the facilities or foundation is ready for examination and the Engineer-In-Charge or his representative shall without unreasonable delay, unless he considers it unnecessary and advises the Contractor accordingly, attend for the purpose of examining and measuring such part of the facilities or of examining such foundations. In the event of the failure of the Contractor to give such notice, he shall, if required by the Engineer-In-Charge, uncover such work at the contractor's expense.
10.16.3.10	The stores received by the BHEL will also be subject to inspection and test as may be considered necessary by the Quality Surveillance Engineer / Customer and his decision as regards rejection of Stores shall be final and binding on the Contractor. If any stores are rejected as aforesaid, without prejudice to the foregoing provision, the BHEL shall be at liberty to: a) Allow the Contractor to resubmit without prejudice to the BHEL's right to claim and recover Liquidated Damages as provided in GCC, Stores in replacement of those rejected within a time specified, the contractor bearing the cost of freight for such replacement without being entitled to any extra payment thereof. b) Buy the quantity of Stores rejected or other items of similar nature from elsewhere at the risk and cost of the Contractor in accordance with the provisions contained in GCC.
10.16.3.11	Any Stores submitted for inspection and rejected by the Inspector must be removed by the Contractor within fourteen days from the date of receipt of intimation of rejection provided that in case of dangerous, infected or perishable Stores, the Inspector (whose decision shall be final) shall notify

	the Contractor to remove such Stores within 48 hours of receipt of intimation of rejection and it shall be the duty of the Contractor to remove such rejected Stores and the same shall lie at the Contractor's risk from the time of such rejection and if not removed within the aforementioned time, BHEL shall have the right either to return the rejected Stores to the Contractor at the Contractor's risk by such mode of transport as BHEL may select, dispose off or segregate such Stores as he thinks fit at the Contractor's risk and on his account and appropriate such portion of the proceeds as may be necessary and recover any damages or expenses incurred by the BHEL in connection with said sale and storage, if any. Freight paid by the BHEL on Stores received and rejected after examination at destination shall be recoverable from the Contractor.
10.16.4	**Remedial Work**
10.16.4.1	If it shall appear to the Engineer-In-Charge or his representative at any time during construction or reconstruction or prior to the expiration of the Guarantee Period, that any work has been executed with unsound, imperfect or unskilled workmanship or that any materials or articles provided by the Contractor for execution of the work are unsound or of a quality inferior to that contracted for or otherwise not in accordance with the Contract that any defect, shrinkage or other faults have appeared in the work arising out of defective or improper materials or workmanship, the Contractor shall, upon receipt of a notice in writing in that behalf from the BHEL, forthwith rectify or remove and reconstruct the work so specified in whole or in part, as the case may require or as the case may be and/or remove the materials or articles so specified and provide other proper and suitable materials or articles so specified and provide other proper and suitable materials or articles at his own expense, notwithstanding that the same may have been inadvertently passed, certified and paid for and in the event of his failing to do so within the period to be specified by the Engineer-In-Charge in his notice aforesaid, the Engineer-In-Charge may rectify or remove and re-execute the work and/or remove and replace with others the materials or articles complained of, as the case may be, by other means at the risk and expense of the Contractor.
10.16.4.2	The Contractor shall uncover any part of the facilities or foundations, or shall make openings in or through the same as the Engineer-in-charge may from time to time require at the Site, and shall reinstate and make good such part or parts.
10.16.4.3	If the Contractor fails to comply with the instruction, BHEL shall be entitled to employ and pay other persons to carry out the work. Except to the extent that the Contractor would have been entitled to payment for the work, the Contractor shall pay to BHEL all costs arising from this failure.

10.16.4.4	Splashes and droppings from white washing, painting etc.; shall be removed and surfaces cleaned simultaneously with completion of these items of work in individual rooms, quarters or premises etc. where the work is done, without waiting for completion of all other items of work in the Contract. In case the Contractor fails to comply with the requirements of this clause, the Engineer-in-Charge shall have the right to get the work done by other means at the cost of the Contractor. Before taking such action however, the Engineer-in-Charge shall give three days notice in writing to the Contractor.
10.17	**AMBULANCE ROOM & EMERGENCY VEHICLE:**
10.17.1	Contractor shall arrange / tie-up with nearest Hospital / Nursing Home to deal with any emergency situation including arrangement of ambulance as and when needed. The availability of the ambulance has to be in accordance with the site working schedule. As the project is having a very tight timeline, round the clock working is envisaged for achieving and meeting the targets.
10.17.2	**AMBULANCE ROOM:**
10.17.2.1	Contractor will have to provide an Ambulance Room in accordance with Contract conditions for Industrial Safety enclosed at Annexure-II.
10.17.2.2	Every ambulance room shall be under the charge of at least one whole-time qualified medical practitioner (hereinafter referred to as medical officer) who shall be assisted by at least one qualified nurse or dresser-cum-compounder and one nursing attendant in each shift. The medical officer shall be readily available on call during working hours of the factory: Provided that where a factory works in more than one shift, the Competent Authority, if it is satisfied that on account of the size of the factory, nature of hazards or frequency of accidents, it is necessary to employ a whole time medical officer for each shift separately, may, order so in writing.
10.17.2.3	There shall be displayed in the ambulance room a notice giving the name, address and telephone number of the medical practitioner in charge. The name of the nearest hospital and its telephone number shall also be mentioned prominently in the said notice.
10.17.2.4	No medical officer shall be required or permitted to do any work which is inconsistent with or detrimental to his responsibilities under this rule.
10.17.2.5	The ambulance room shall be separate from the rest of the factory and shall be used only for the purpose of first-aid treatment and rest. It shall have a floor area of at least 24 sq.m. and smooth, hard and impervious walls and floors, and shall be adequately ventilated and lighted by both natural and artificial means. There shall be attached to it at least one latrine & urinal of sanitary type. An adequate supply of wholesome drinking water shall be laid on and the room shall contain at least the following, namely:-

	(a) A glazed sink with hot and cold water always available. (b) A table with a smooth top at least 180 cm X 105 cm. (c) Means for sterilizing instruments. (d) A couch. (e) Two stretchers. (f) Two buckets or containers with close fitting lids. (g) Two rubber hot water bags. (h) A kettle and spirit stove or other suitable means of boiling water. (i) Twelve plain wooden splints 900 mm X 100 mm X 6 mm. (j) Twelve plain wooden splints 350 mm X 75 mm X 6 mm. (k) Six plain wooden splints 250 mm X 50 mm X 12 mm. (l) Six woolen blankets. (m) Three pairs of artery forceps. (n) One bottle of spiritus ammoniac aromaticus (120 ml) (o) Smelling salts (60 gm). (p) Two medium size sponges. (q) Six hand towels. (r) Four "Kidney" trays. (s) Four cakes of toilet, preferably antiseptic soap. (t) Two glass tumblers and two wine glasses. (u) Two clinical thermometers. (v) Two tea spoons. (w) Two graduated (120 ml) measuring glasses. (x) Two minim measuring glasses. (y) One wash bottle (1000 cc) for washing eyes (z) One bottle (one litre) carbolic lotion 1 in 20. (aa) Three chairs. (bb) One screen. (cc) One electric hand torch. (dd) Four first-aid boxes or cupboards stocked to standards prescribed under(c)of rule 59. (ee) An adequate supply of anti-tetanus toxiod. (ff) Injections - morphia, pethidrine, atropine, adrenaline, coramine, novocain (6 each). (gg) Coramine liquid (60 ml). (hh) Tablets -25 each of antihistaminic, antispasmodic. (ii) Syringes with needles - 2 cc, 5 cc, 10 cc and 50 cc. (jj) Three surgical scissors. (kk) Two needle holders, big and small. (ll) Suturing needles and materials.

	(mm) Three dissecting forceps. (nn) Three dressing forceps. (oo) Three scalpels. (pp) One stethoscope. (qq) Rubber bandage - pressure bandage. (rr) Oxygen cylinder with necessary attachments.
10.17.2.6	The occupier of every factory to which these rules apply shall for the purpose of removing serious cases of accidents or sickness, provide in the premises and maintain in good condition a suitable conveyance unless he has made arrangements for obtaining such a conveyance from a hospital.
10.17.2.7	The Competent Authority may, by an order in writing exempt any factory from the requirements of this rule, subject to such conditions as it may specify in that order, if a hospital, ambulance room or dispensary is maintained at or within 200 m. of the precincts of the factory and such arrangements are made as to ensure the immediate treatment of all injuries sustained by workers within the factory and for providing rest to the workers so injured. **Explanation:-** For the purpose of this rule, "qualified medical practitioner" means a person holding a qualification granted by an authority specified in the schedule to the Indian Medical Degrees Act, 1916 (7 of 1916), or in the schedules to the Indian Medical Council Act, 1956 (102 of 1956).
10.17.2.8	**Note: Contractor to note that requirement of above Ambulance Room is also kept under the scope of other contractors deployed by BHEL for the project work. Contractor can tie-up with other contractors of BHEL for setting up, running and maintenance of Ambulance Room on cost sharing basis with the written permission of BHEL. In case contractor is not able to tie-up and unless the requirement of Ambulance Room is not waived off by the competent authority, contractor has to construct and maintain all the facilities required for the services of Ambulance Room as stated above at his own cost.**
10.18	**METHOD OF MEASUREMENT**
10.18.1	Method of measurements shall be as per standard specifications included in the tender. For other items measurements shall be as per relevant IS Codes.
10.19	**DEVIATION**
10.19.1	The Contractor shall not make any alteration in, addition to or omission from the work as described in the tender documents except in pursuance of the written instructions of the Engineer. No such deviation from the work described in the tender documents shall be valid unless the same has been specifically confirmed and accepted by the Engineer in writing and incorporated in the Contract.

10.19.2	The Engineer may deviate, either by way of addition or deduction, from the work so described, provided that the Contract sum be not thereby varied on the whole by more than the percentage set out in the tender documents. The value of all additions and deductions shall be added to or deducted from the Contract sum. (Whenever the Engineer intends to exercise such a right his intentions shall specify the deviations which are to be made, the lump-sum assessment or the proposed basis of payment, the extra time allowed, if any, and the date for completion of the entire contract). Any objection by the contractor to any matter concerning the order shall be notified by him in writing to the Engineer within seven days from the date of such order, but under no circumstances shall the work be stopped (unless so ordered by the Engineer) owing to differences or controversy that may arise from such an objection. In the absence of such a notification of objection by the Contractor, he will be deemed to have accepted the order and the conditions stated therein.
10.19.3	Valuation of Deviations shall be as per Clause 2.15 & 2.16 of GCC.
10.20	**COMPLIANCE TO REGULATIONS AND BYELAWS**
10.20.1	The Contractor shall conform to the provisions of any statute relating to the work and regulations and bylaws of any local authority and of any water and lighting Companies or Undertaking with whose system the work is proposed to be connected. He shall, before making any variation from the drawings or the specifications that may be necessitated for such connections give the Engineer, notice specifying the variation proposed to be made and the reasons therefore and shall not carry out any such variation until he has received instructions from the Engineer in respect thereof. The Contractor shall be bound to give all notices required by statute, regulations or bye-laws as aforesaid and to pay all fees and taxes payable to any authority in respect thereof.
10.20.2	**In order to give phillip to Pradhan Mantri Kaushal Vlkas Yojna:** "The contractor shall, at all stages of work deploy skilled/semi-skilled tradesmen who are qualified and possess certificate in particular trade from CPWD Training Institute/ Industrial Training Institute/ National Institute of Construction Management and Research (NICMAR), National Academy of Construction, CIDC or any similar reputed and recognized Institute managed/ certified by State/ Central Government. The number of such qualified tradesmen shall not be less than 20% of total skilled/ semi-skilled workers required in each trade at any stage of work. The contractor shall submit

	number of man days required in respect of each trade, its scheduling and the list of qualified tradesmen along with requisite certificate from recognized Institute to Engineer-in-Charge for approval. Notwithstanding such approval, if the tradesmen are found to have inadequate skill to execute the work of respective trade, the contractor shall substitute such tradesmen within two days of written notice from Engineer-in-Charge. Failure on the part of contractor to obtain approval of Engineer-in-Charge or failure to deploy qualified tradesmen will attract a compensation to be paid by contractor at the rate of Rs. 100 per such tradesman per day. Decision of Engineer-in-Charge as to whether particular tradesman possesses requisite skill and amount of compensation in case of default shall be final and binding.
10.21	**PROGRESS REPORTING :**
10.21.1	Contractor is required to draw mutually agreed monthly programme in consultation with BHEL well in advance. Contractor shall ensure achievement of agreed programme and shall also timely arrange additional resources considered necessary at no extra cost to BHEL.
10.21.2	Weekly progress review meetings will be held at site during which actual progress during the week vis-a-vis scheduled programme shall be discussed for actions to be taken for achieving targets. The programme for subsequent week shall also be presented by contractor for discussions. The contractor shall constantly update / revise his work programme to meet the overall requirement. All quality problems shall be discussed during above review meetings. Necessary preventive and corrective action, shall be discussed and decided upon in such review meetings and shall be implemented by the contractor in time bound manner so as to eliminate the cause of non-conformities.
10.21.3	The contractor shall submit weekly and monthly progress reports, materials reports, consumables (gases / electrodes) report and other reports as per proforma considered necessary by the Engineer.
10.21.4	The progress report shall indicate the progress achieved against planned , with reasons indicating delays , if any, and shall give the remedial actions which the contractor intends to take to make good the slippage or lost time , so that further works again proceed as per the original programme and the slippages do not accumulate and effect the overall programme.

10.21.5	The daily manpower reports shall clearly indicate the manpower deployed, category wise specifying also the activities in which they are engaged.
10.22	**DRAWING AND DOCUMENTS**
10.22.1	The detailed drawings, specifications available with BHEL engineers will form part of this tender specification. These documents will be made available to the contractor during execution of work at site. The contractor will also ensure availability of all drawings / documents at work place.
10.22.2	Necessary drawings / documents by BHEL to carry out the construction work will be furnished to the contractor by BHEL (except those proposed to be prepared by contractor, as mentioned in this contract) on loan which shall be returned to BHEL Engineer at site after completion of work. Contractor shall ensure safe storage and quick retrieval of these documents.
10.22.3	The contractor shall maintain a record of all drawings and documents available with him in a register as per format given by BHEL Engineer. Contractor shall ensure use of pertinent drawings / data / documents and removal of obsolete ones from work place and return to BHEL.
10.22.4	The data furnished in various annexures enclosed with this tender specification are only approximate and for guidance. However, the change in the design and in the quantity may occur as is usual in any such large scale of work.
10.22.5	Should any error or ambiguity be discovered in the specification or information the contractor shall forthwith bring the same to the notice of BHEL before commencement of work. BHEL's interpretation in such cases shall be final and binding on the contractor.
10.22.6	Deviation from design dimensions should not exceed permissible limit. The contractor shall not correct or alter any dimension / details, without specific approval of BHEL**.**

Annexure-I: BOQ cum Rate Schedule for the Work of **"**CIVIL, STRUCTURAL, ARCHITECTURAL AND ASSOICIATED WORKS OF ELECTRICAL BAY BUILDINGS FOR 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2"

Annexure II: NPCIL SAEFTY GUIDELINES

a) Contract Conditions for Industrial Safety
b) AERB Safety Guidelines (Control of Works)

UN-PRICE SCHEDULE

ITEM NO.	DESCRIPTION OF WORK	TOTAL VALUE IN INR
1.0	TOTAL PRICE ('A') FOR THE TOTAL WORK AS PER TENDER SPECIFICATION FOR "CIVIL, STRUCTURAL, ARCHITECTURAL AND ASSOICIATED WORKS OF ELECTRICAL BAY BUILDINGS FOR 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA-UNIT NO. 1&2."	

Notes:

a. **The rate of individual item for the entire scope of work shall be arrived as per BOQ CUM RATE SCHEDULE (Annexure - I) of TCC of tender.**

b. **The derived item rate will remain firm throughout the contract period.**

Notes:

i. Bidder's quoted price above shall be complete in all respect for the full scope defined in specification and in accordance with all terms & conditions of tender.
ii. Contractor shall fully understand description and specifications of items mentioned in BOQ.
iii. Conditional price bids with any deviation/ clarification etc. are liable to be rejected. No cutting/ erasing/ over writing shall be done.
iv. Quantities mentioned in rate schedules are approximate only and liable for variation on either side depending upon site/ design requirement.
v. Taxes (GST) shall be payable extra as per relevant clauses of Technical Conditions of Contract.

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
100	**EARTH WORK: Earth work In excavation, backfilling, disposal, dewatering, ground improvement including all labour, equipments etc complete as per specification, drawing and as directed by engineer- in-charge for the following.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, Inspection and testing plan, and acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, pour cards, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specificaiton and as directed by engineer - in - charge)**					
101	Earth work in excavation in all types of soil including ash which can be excavated by any means including setting out, levelling, dewatering (but excluding special type of dewatering viz. well point method), shoring & strutting (wherever required), dressing the sides & bottom, all lifts, ramming/ compacting the excavated bottom, stacking, disposal of surplus excavated materials within a lead upto **4 km**, spreading/ levelling of disposed materials etc all complete for following depths below ground level.					
a	Depth from **existing** ground level but not exceeding 2 m	CUM	50	0.776707	-	-
A101	Earth work in excavation in all types of **COMPACTED SOIL-CEMENT MIX** including ash which can be excavated by any means including setting out, levelling, dewatering (but excluding special type of dewatering viz. well point method), shoring & strutting (wherever required), dressing the sides & bottom, all lifts, ramming/ compacting the excavated bottom, stacking, disposal of surplus excavated materials within a lead upto **4 km**, spreading/ levelling of disposed materials etc all complete for following depths below ground level.					-
a	Depth from **existing ground** level but not exceeding 2 m	CUM	100	1.509533	-	-
b	Depth exceeding 2 m but not exceeding 4 m	CUM	50	1.746495	-	-
c	Depth exceeding 4 m but not exceeding 6 m	CUM	50	2.049279	-	-
102	Extra over ST No. 101 for dewatering of ground water by well point method as per IS 9759. **(Measurement will be made for earth work done beyond the depth of water table, where de-watering by well-point method is required for excavation purpose.)**	CUM	200	0.280843	-	-
109	Extra over ST No. 101, A101 and 103 to 108 for carriage of material/ earth for every 500 m or part thereof beyond an initial lead of **4 km**.				-	-
a	Carriage for stacking/ backfilling of servieable material/ earth/ soil cement mix	CUM	50	0.039494	-	-
b	Carriage for disposal of servieable/ unserviceable material/ earth/ soil cement mix	CUM	200	0.039494	-	-
A110	Earth work in backfilling upto any depth below ground level around foundations, plinths, trenches, drains etc. to proper grade and level in layers not exceeding 200 mm compacted thickness so as to achieve required compaction with approved borrowed soil **(borrowed soil to be arranged by the bidder)** and compacted as specified including supplying boorowed soil, royalty/ seignorage fee (if any), sorting, spreading, breaking clods, watering, ramming/ compaction by manual/ mechanical means, dressing, finishing to required lines, grades and slopes, tesing, all lead and lifts etc all complete as per specification, drawing and as directed by the engineer for the following:				-	-
a	Each layer compacted so as to achieve at least 90% maximum dry density as per IS-2720 (Part-VIII)	CUM	200	1.075104	-	-
b	Each layer compacted so as to achieve at least 95% maximum dry density as per IS-2720 (Part-VIII)	CUM	100	1.184808	-	-
111	Supplying and filling sand (the sand used should be clean, well graded and be of the quality normally acceptable for use in concrete) upto any depth under floors, around foundations, plinths etc. in layers not exceeding 200 mm compacted thickness and compacted so as to achieve at least 80% relative density as per IS-2720 (Part-XIV) including spreading, watering, ramming/ compaction by manual / mechanical means, dressing, royalty (if any) etc. all complete.	CUM	20	7.394080	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
A112	Supply and filling upto any depth below ground level around foundations, plinths, trenches, drains etc by using compacted soil-cement mix (cement content 5% by weight of dry soil) as per technical specifications and drawings. For the above purpose, selected earth free from pabbles and vegetation after recovering from the stacks of excavated soil shall be dried in drying beds before use so as to bring moisture content below/ equal to Optimum Moisture Content (OMC). The soil and cement in specified quantity shall be uniformly mixed in automated weigh batching and mixing plant(s). Suitable quantity of water shall then be added to this mix in batching and mixing plant so as to achieve desired OMC at site. This mix shall be transported to the placement locations and laid in layers not exceeding 200 mm each (compacted thickness) and compacting each layer at optimum moisture content using vibro rollers to achieve at least 95% Modified Procter Density which shall be verified after completion of compaction through field and laboratory tests as per technical specifications. Quoted rate shall include cost of transportation of soil from stock pile and drying beds, bringing moisture content of soil-cement to required level, uniform mixing of soil-cement in automated weigh batching and mixing plant(s), transporting soil-cement mix to placement locations, spreading in layers, compaction, curing, protecting and performing required tests as per specifications, including maintaing and submitting all the records. Quoted rate shall also include provision of all equipment, tools & plants, manpower, consumables, enabling works required for carrying out ground improvement, necessary arrangements for testing and conducting trials and offering the same for inspection to NPCIL. **(Cement will be supplied by BHEL and issued as FOC Item)**	CUM	400	6.239989	-	-
200	**CONCRETE WORK: Providing and placing concrete work including cost of labour, materials, (unless otherwise specified in BOQ/ contract specification) and equipment for handling, transportation, batching, mixing, placing, vibrating, compacting and curing (excluding cost of centering, shuttering and reinforcement) with mechanised equipments like batching plant, chilling plant, transit mixer, concrete pump etc. complete as per drawing, relevant codes, specifications and as per direction of engineer in charge for the following.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, source qualification of construction material, construction completion certificate, transfer docket containing necessary documents like test certificate, pour cards, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).** **(Ready Mix Concrete upto the point of pouring including batch mixing, transportation in transit mixers and placing through Boom placer/ concrete pump will be in the scope of BHEL's RMC agency deployed at site and Ready Mix concrete will be issued to contractor as Free of Cost (FOC) Item).**				-	-
A204	Concrete under floors, paving, lean concrete, levelling course, mud mat under and around foundations/ floors, plinth protection, pipe encasing, roads, drain etc. with coarse sand and graded hard stone aggregate of 20mm nominal size at any depth below/ above finished ground floor level for the following grades.				-	-
b	M15 Grade	CUM	400	2.474932	-	-
c	M20 Grade	CUM	20	2.474932	-	-
A205	Laying Design Mix cement concrete conforming to IS:456 & IS 10262 for reinforced concrete works with coarse sand and graded hard stone aggregate of 20mm nominal size in **foundations/ substructure**, grade slab, paving, drains, under floors etc. at any level below finished ground floor level, any shape, position or thickness, F3/ U3 finish of concrete surfaces, green cutting using coloured surface retarder at construction joints, testing & preparation of construction joint, etc. to achieve required slump, strength, durability, quality etc. in concrete all complete as per specification & drawing for the following				-	-
a	M 25 Grade	CUM	200	2.474932	-	-
b	M 35 Grade	CUM	3500	2.474932	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
A206	Laying Design Mix cement concrete conforming to IS:456 & IS 10262 for reinforced concrete works with coarse sand and graded hard stone aggregate of 20mm nominal size in **superstructure** at any level above finished ground floor level, any shape, position or thickness, F3/ U3 finish of concrete surfaces, green cutting using coloured surface retarder at construction joints, testing & preparation of construction joint etc. to achieve required slump, strength, durability, quality etc. in concrete all complete as per specification & drawing for the following.				-	-
a	M 25 Grade	CUM	200	2.474932	-	-
b	M 35 Grade	CUM	8900	2.474932	-	-
A211	Encasing of structural steel member with following grade of concrete using coarse sand and nominial hard stone aggregate size of 12.5mm down at all elevations, any shape, position or thickness, F3/ U3 finish of concrete surfaces, etc. to achieve required slump, strength, durability, quality etc. in concrete all complete as per specification & drawing. Encased member shall be wrapped with welded wire mesh/ chicken wire mesh with proper lap etc. complete as per specifications. **(Payment of welded wire mesh, chicken wire mesh shall be made separately)**				-	-
a	M 35	CUM	20	2.474932	-	-
A212	Laying of Screed concrete conforming to IS 456 with coarse sand and graded hard stone aggregate 10mm nominal size on the roof, drains, sumps etc. at any level, any shape, position or thickness, F3/ U3 finish of concrete surfaces to achieve required slump, strength, durability, quality etc. in concrete all complete as per specification & drawing for the following..				-	-
a	M 15	CUM	200	2.474932	-	-
b	M 20	CUM	180	2.474932	-	-
A213	Laying Design Mix cement concrete as per IS:456 & IS 10262 for reinforced concrete works with coarse sand and graded hard stone aggregate (20/ 12.5/ 10 mm) for Concrete in **precast works** like floors, roof slabs, trench covers, fins, lintels, chajas, beams, columns, wall panels, facias etc. at all levels in all kinds of works, any shape, position or thickness, F3/ U3 finish of concrete surfaces, including formwork/ moulds, curing, handling, storing, transpoting, all leads, marking, making of holes for bolts for fixing, welding, erection without damage, setting in position with cement sand mortar (1:3), filling the gaps between adjacent preacast units with M35 grade concrete or cement sand mortar (1:3) including use of mineral admixture, plasticizer/ superplasticizer/ admixtures conforming to ASTM C-494/ IS:9103 to achieve required slump, strength, durability, quality etc. in concrete all complete as per specification and drawing for following grades. **(Ready Mix concrete for precast work and cement for preparing cement sand mortar will be issued to contractor as FOC Item.)**				-	-
a	M35	CUM	20	12.010443	-	-
B213	Extra over ST NO. A213 for providing and filling the gaps with polystyrene backing and poly sulphide sealant instead of cement sand mortar/ M35 grade of concrete etc. all complete as per specfication and drawing.	CUM	20	28.694295	-	-
A214	Laying Design Mix cement concrete as per IS:456, IS 3370 & IS 10262 for reinforced concrete works with coarse sand and graded hard stone aggregate for Concrete **in water retaining/ conveying structures/ tunnels** at any level, any shape, position or thickness, F3/ U3 finish of concrete surfaces, green cutting using coloured surface retarder at construction joints, testing & preparation of construction joint etc. to achieve required slump, strength, durability, quality etc. in concrete all complete as per specification & drawing for the following. Watertightness is to be ensured including structural grouting if required				-	-
a	M35	CUM	400	6.424292	-	-
215	Dismantling concrete work for all types of structures at all levels including stacking of servicable material to a lead of 500 m and disposal of unservicable material upto a lead of 4 km, cutting of reinforcement, labour, equipment, safety precautions etc all complete as per drawings, specification and instructions of engineer in charge.				-	-
a	Plain cement concrete of all grades	CUM	10	7.473067	-	-
b	Reinforced cement concrete of all grades	CUM	70	10.878293	-	-
216	Chipping of concrete in reinforced concrete work, cutting pockets, making openings at all levels and according to shapes, disposal of waste materials upto a lead of 4 km as directed by engineer including equipment, safety precautions, making good the broken surface etc all complete as per specification, drawing, instructions of engineer in charge but excluding cutting of reinforcement .	CUDM	350	0.355442	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
217	Extra over and above St No 216 for cutting of reinforcement, all sizes and types including labour, equipment, return of cut reinforcement to store etc all complete as per specification, drawings and instructions of engineer in charge. Measurement shall be on the cross sectional area of reinforcement cut.	SQCM	140	0.026329	-	-
218	Cutting Reinforced concrete with mechanised tools like Core drilling machine etc. for cutting pockets, holes, cores in slab, beam, column or foundation as per direction of engineer in charge.	CUDM	40	0.456370	-	-
219	Providing and applying curing compound (water based) of approved make where ever required as per manufacturer's specification.	SQM	500	0.487088	-	-
A222	Cutting in construction joints, expansion joints, in RCC walls, slabs, paving, hatch covers etc. of V groove size varying from 12 mm X 12 mm to 25 mm X 40 mm and for rectangular gap varying from 25 mm X 10 mm to 75 mm X 10 mm thick using groove cutting machine in concrete etc. all complete as per specification & drawing.	RM	2000	0.631898	-	-
A223	Cutting of existing concrete/ RCC slab (total thickness upto 250mm including floor finsih & deck sheet if any) in buildings or structures or anywhere inside boundary using power tools of (DD2E of HILTI/ BOSCH make or equivalent) with low noise and dust including cutting reinforcements, removing the rubbish within a lead of 4 km, including making good the broken edges/ surface with cement mortar, painting, finishing to match with existing finishing, scaffolding/ supporting at all level, all complete and as directed by Engineer (measurements shall be taken as per cutting surface area)	SQM	100	12.243016	-	-
300	**FORMWORK: Providing, designing, fabrication, erection, fixing and removing formwork at all elevations for all structures, as per specifications and including all labour, material, scaffoldings, supporting system, working platform and centereing etc. complete as per drawing, specifications and as per direction of engineer in charge for the following.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, construction completion certificate, transfer docket containing necessary documents like test certificate, pour cards, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge)**				-	-
301	Fairface form work with good quality water proof ply wood of minimum 12mm thickness and smooth surface below finished ground floor level for foundations, footings, base of columns, walls, columns, pilasters, beams, mass concrete, trenches etc.including chamfering of edges as per drawing, specification and instruction of engineer in charge.	SQM	500	2.391557	-	-
A301	Fairface form work with good quality water proof plywood of minimum 12mm thickness conforming to IS:4990 and **smooth concrete surface finish of F3/ U3**, **backed with steel framework Acro/ DOKA or equivalent** including braces, props, shores, H frames, built-up sections, rolled sections, struts, anchors, inserts, hangers, false works, wedges, ties, buffle plates, walers, ledges, temporary openings, recesses filling with caulking compound or epoxy mortar, stopper formwork, supporting system etc., **below finished ground floor level at all heights** for foundations, footings, base of columns, walls, columns, pilasters, beams, mass concrete, trenches, tunnels, floors, suspended floor, chamfering of edges etc. including **preparation of scheme, submission and approval of design & drawing** etc. all complete as per drawing, specification and instruction of engineer in charge.	SQM	8000	4.739232	-	-
A302	Fairface form work with good quality water proof plywood of minimum 12mm thickness conforming to IS:4990 and **smooth concrete surface finish of F3/ U3, backed with steel framework Acro/ DOKA or equivalent** including braces, props, shores, H frames, built-up sections, rolled sections, struts, anchors, inserts, hangers, false works, wedges, ties, buffle plates, walers, ledges, temporary openings, recesses filling with caulking compound or epoxy mortar, stopper formwork, supporting system etc., **above finished ground floor level at all heights** for columns, beams, suspended floors, roofs, lintels, cantilevers, staircases, landings, balconies, mass concrete, chamfering of edges etc. **including preparation of scheme, submission and approval of design & drawing** etc. all complete as per, specification, drawing and instruction of engineer in charge	SQM	33200	5.726572	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
B302	Fairface **suspended formwork by providing structural steel trusses / beams spanning across the entire width of slab and keeping the area below free of obstructions** with good quality water proof plywood **backed with steel/ DOKA framework and support of minimum 12mm/ 16mm** thickness and smooth surface **below finished ground floor/ above finished ground floor** for columns, beams, suspended floors, roofs, lintels, cantilevers, staircases, landings, balconies, etc. including chamfering of edges as per drawing.for all heights as per specification, drawing and instruction of engineer in charge. **The rate shall be inclusive of structural steel supporting arrangement**	SQM	500	11.031879	-	-
304	Providing, fixing and removing formwork in block-outs/ pockets and openings (below 0.1 sqm plan area) at all elevations including cutting, formation of all shapes and all other operations required for making the required shape and size all complete as per specification, drawing and instruction of engineer in charge.				-	-
a	Upto 150 mm depth	Each	400	1.039998	-	-
b	Pockets of depths more than 150mm and upto 300 mm depth	Each	200	1.807929	-	-
c	Pockets of depths more than 300mm and upto 600 mm depth	Each	100	3.313074	-	-
d	Pockets of depths more than 600mm and upto 1000 mm depth	Each	40	5.270202	-	-
e	Pockets of depths more than 1000mm and upto 1500 mm depth	Each	50	7.679311	-	-
f	Pockets of depths more than 1500mm and upto 2000 mm depth	Each	50	10.163020	-	-
A305	Extra over item no.A301, A302 and B302 for curved form work for foundations, footings, beams, walls, trenches, domes, arches etc as per specification.				-	-
a	Extra for Curve Shuttering for Item No. A301	SQM	200	1.948351	-	-
b	Extra for Curve Shuttering for Item No. A302	SQM	100	2.123878	-	-
c	Extra for Curve Shuttering for Item No. B302	SQM	100	2.558308	-	-
400	**REINFORCEMENT WORK : Reinforcement work including all labour, material (unless otherwise specified in BOQ/ contract specification), equipment, transportation, handling etc. at all level as per specification, drawings and as directed by engineer - in - charge for the following:** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge)** **(Reinforcement Steel, HYSD TMT steel of grade Fe-500 confirming to IS:1786 will be supplied by BHEL and issued as Free of Cost (FOC) Item)**				-	-
401	Providing, straightening, cutting, bending, placing in position at all level, binding of mild steel reinforcements conforming to grade 1 of IS:432 part 1 in concrete including cost of reinforcement steel, binding wire, labour, scaffolding, transportation to & from stores etc. all complete as per specifications & drawings.	MT	20	387.594585	-	-
A402	Straightening, cutting, bending, placing in position at all level, binding in position of steel reinforcements of HYSD TMT steel of grade Fe-500 confirming to IS:1786 including cost of 1.6 mm dia soft annealed iron binding wire, fixing parallel square threaded reinforcement couplers for mechanical splices of rebars (HYSD TMT) for concrete reinforcement including cleaning, fitting & fixing of couplers under specialized supervision, quality tests & checks (for couplers and coupled joints), couplers shall be of same quality or superior quality than the quality of material of parent bars, couplers qualified as per ASME, Section III, Div.2. and IS16172, labour, scaffolding, cover blocks, protection of exposed ends of reinforcement bars with adequate coat of cement wash and plastic tape, transportation to & from stores, test, test report, preparation of bar bending schedules etc. complete all as per specifications, drawings and as directed by Engineer. **For Fe 500 grade steel, the total elongation shall be more than 14.5 % and the ultimate tensile strength of the bar shall be 15 % more than the specified 0.2 % proof stress/ yield stress. This requirement is over and above the requirements specified in IS1786.** **(Couplers will be supplied by BHEL and issued as FOC Item)**	MT	2050	47.251899	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
405	Fixing of Rebar in existing concrete surface by inserting reinforcemnet bar with Epoxy based suitable bonding compound of Hilti or equivalent make (HIT-RE-500 of Hilti or equivalent make) for interconnection of new R.C. structure with existing R.C. structure. Depth of drilled hole should be suitable to develop maximum recommended strength as per approved manufacturer's recommendation. This item includes supply of all materials including bonding chemicals, T&P required to execute the work, cost of all labour, transportation of chemical, staging to reach work place etc. all complete as directed by Engineer - in - Charge. Random Pull out non destructive test as directed by engineer shall be conducted to ensure strength of bond and same is included in this item. **Reinforcement bar shall be measured and paid separately under relevant BOQ item.**				-	-
a	10mm Reinforcement bar	Each	400	1.544639	-	-
b	12mm Reinforcement bar	Each	400	1.715778	-	-
c	16mm Reinforcement bar	Each	100	2.716282	-	-
d	20mm Reinforcement bar	Each	100	3.835267	-	-
e	25mm Reinforcement bar	Each	100	4.686574	-	-
A406	Extra over Item No. A402 for threading on rebars to be coupled with coupler, enlargement at connection by forging, protecting the prepared reinforcement bars including moblisation, demobilisation, loading/ unloading of required plant/ machinery at site for threading & forging works, tools & tackles, transportation to & from stores, scaffolding, labour & supervision, training, consumables and all incidental expenses for satisfactory execution of the works etc. all complete as per specification and direction of Engineer in charge. **(Measurement will be done for each coupled joint. For each coupled joint, threading shall be done on both side reinforcement.)**				-	-
c	Coupler of class "H" for 20 mm diameter reinforcement bar.	Each	400	0.236962	-	-
d	Coupler of class "H" for 25 mm diameter reinforcement bar.	Each	4000	0.246835	-	-
e	Coupler of class "H" for 28 mm diameter reinforcement bar.	Each	2000	0.252759	-	-
f	Coupler of class "H" for 32 mm diameter reinforcement bar.	Each	4000	0.260658	-	-
g	Coupler of class "H" for 36 mm diameter reinforcement bar.	Each	1000	0.268556	-	-
407	Providing, straightening cutting, bending, placing in position at any level, binding of mild steel reinforcements in brickwork including cost of reinforcement and binding wire, labour, scaffolding etc. complete all as per specifications & drawings.	MT	5	387.594585	-	-
408	Straightening, cutting, bending, placing in position at any level, binding in position high yield strength steel TMT reinforcements in brickwork including cost of binding wire, labour, scaffolding etc. complete all as per specifications & drawings.	MT	10	47.251899	-	-
500	**Water proofing works: Water proofing of underground works, water proofing of roof treatment works including all labour, material (unless otherwise specified in BOQ/ contract specification), equipment, transportation, handling, curing, sampling, testing, preparation of work procedure & inspection and test plan, submission of reports and getting approval etc. at all levels as per specification, drawings and as directed by engineer - in - charge for the following.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).**				-	-
A503	Providing and laying **75 mm thick polyurethane foam (PUF) thermal insulation of approved make** with two component high density spray applied polyurethane resin foam complying with class B2 of DIN 4102 Part 1 and properties, test methods & acceptance values specified in specficiations including preparation of surface, spray application using specially designed spraying machine etc. as per specifications, approved drawing or as directed by the Engineer in charge. Cost shall also include making of fillets, water ponding test & rectification of leakage/ seepage of roof slab prior to laying of insulation, cleaning & preparation of surface, expansion joints and sealing at suitable intervals etc. all complete as per specifications and direction of engineer in charge.	SQM	1900	8.407749	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
A506	Providing and applying **solvent free, spray applied, two component polyurethane (PU) membrane with high solid content (minimum 90%)** of approved make comprising of (Total DFT 2200 micron exluding DFT of primer) 2000 micron thick (DFT) aromatic/ aliphatic PU membrane base coat with 200 micron thick (DFT) protective UV resistant aliphatic PU top coat over one coat of two pack epoxy primer 75 micron DFT including broadcasting of dried graded silica sand (0.3 to 0.9 mm) at the rate of 0.8 to 1.0 kg/ sqm on primer coat prior to its hardening. Properties of materials, test methods & acceptance values shall be as per specifications and relevant IS/ ASTM standards.The coating shall have high viscosity, min.450% elongation and forming a perfectly smooth permanently flexible seamless membrane which should have good adhesion to roof substrates.The cured film should have a very low water absorption rate (0.5% maximum at ambient temperature after 7 days).Cost shall also includes surface preparation, polyscrim cloth / fabric(non woven polyscrim cloth of 100% polyester with min. weight of 40gsm/ sqm), polymerised mortar base preparation, making of fillets, conduting tests like solid content, density, tensile strength, compressive strength, bond strength, elongation, hardness etc in laboraties like IITs, ICT or Goevernment approved/ NABL accredited labs, pull out adhesion test at site using pull out adhesion tester, water ponding test after roof water treatment & suitable rectification (if required), cleaning & preparation of surface, vaccum removal of loose sand, expansion joints & sealing at suitable intervals, application by using a pneumatic machine as per manufactures specificaitons etc. all complete as per specifications, drawings and direction of engineer in charge. **(Measurement shall be of the concrete surface area covered by water proofing membrane).** **The Contractor shall make periodical inspection and repair the waterproofing for any apparent defects to ensure complete waterproofing during the guarantee period. The Contractor shall submit a bank guarantee from a scheduled commercial bank (other than co-operative bank) for an amount of 10% of the cost of water proofing works carried out. The bank Guarantee shall be valid for a period of ten (10) years from the date of acceptance of the water proofing work by NPCIL.**	SQM	1900	4.279132	-	-
A508	Providing and laying wearing course consisting of **50mm thick concrete of grade M15** with graded aggregate of maximum 10 mm size cast in panels of maximum size 2 m x 2 m with an expansion groove of 10 mm wide and 15 mm deep between the panels including sealing of expansion groove with polyurethane sealant etc. all complete as per specifications and direction of engineer in charge. **(RMC concrete will be supplied by BHEL's RMC agency and issued to contractor as Free of Cost (FOC) Item).**	SQM	1900	1.513921	-	-
511	Providing and applying two coats of bitumen grade 85/ 25 as per IS 702 (@ 1.7kg/ sqm) with 1% antistripping compound conforming to IS 6241 in foundation, wall, column etc on concrete surfaces exposed to soil / ash including surface preparation etc. all complete.	SQM	1900	0.592404	-	-
513	Providing and mixing water proofing compound conforming to IS:2645 in concrete or cement mortar all complete.	KG	400	0.491476	-	-
514	Providing and applying concrete structures two coats of ERPB (Epoxy rasin based anticorrosive and chemical resistant paint) over a coat of CPCI (concrete penetrating bipolar corrosion inhibitor) with 300 to 325 micron DFT for protection of concrete against carbonation and chloride penetration in saline/ marine enviornment all complete of approved make and as per manufacturer's recommendation.	SQM	200	1.794765	-	-
					-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
A518	Providing and laying **single ply twin colored of minimum 2.0 mm thick plasticized PVC waterproofing membrane** system with **two layers (one layer before and one layer after PVC membrane) of geo-textiles made of needle punch 100 % pure polypropylene yarns with minimum weight 300 gsm** for all horizontal and vertical surfaces of underground structures i.e. basement, sumps, pits, tunnerls, trenches etc. including preparing the concrete surface, fixing the overlaps of PVC membrane with hot air welding, including compartmentalisation using 320 mm wide and 2.5 mm thick PVC surface water stop having minimum 4 ribs of 15 mm depth, hot air welding of water stop with PVC membrane, roundels (max spacing 1.0 m c/ c) with mechanical fixtures, testing of joints, dressing up of pile head with pvc membrane and encapsulated with high strength flowable epoxy mortar minimum 10 mm below the membrane and 20 mm top of it and extended to the edge of outer surface of interface etc. all complete as per specifications, manufacturer's recommendation, drawings and as directed by the Engineer. Cost shall also include conduting tests like ultimate tensile strength, elongation and puncture resistance, thickness etc. in laboraties like IITs, ICT or Government approved/ NABL accredited labs, preparation of detailed scheme including layout of pvc water storp arragement, compartmentalisation etc. all complete as per specifications, drawings and direction of engineer in charge. The laying of membrane shall be got done through the authorised applicator of the manufacturer of membrane. The testing of material shall be done from authorised lab same shall be furnished before execution of work,as directed by engineer in charge.Performance Guarantee should be given by the manufacturer after completion of the water proofing work for 10 years for material and workmanship. **(Measurement shall be of the concrete surface area covered by water proofing membrane).** **The Contractor shall make periodical inspection and repair the waterproofing for any apparent defects to ensure complete waterproofing during the guarantee period. The Contractor shall submit a bank guarantee from a scheduled commercial bank (other than co-operative bank) for an amount of 10% of the cost of water proofing works carried out. The bank Guarantee shall be valid for a period of ten (10) years from the date of acceptance of the water proofing work by NPCIL.**	SQM	2400	3.949360	-	-
B518	**Providing and laying one layer of pre-applied fully bonded 1.2mm (min) thick HDPE water proofing membrane** consisting of HDPE sheet (HDPE should be virgin HDPE & not recycled, thickness of bare HDPE layer shall not be less than 0.75mm) coated with pre-applied pressure sensative adhesive layer and a trafficable, non sticky, sand finish/ smooth finish, weather & dirt resistant, non absorbant protective coating covered with a clear release liner for horizontal and vertical surfaces of underground structures i.e. basement, sumps, pits, tunnerls, trenches etc. including preparing the concrete surface, fixing the overlaps of adjacent HDPE membrane (minimum overlap of 80mm) , vapour barrier, polyethylene of 0.25mm thick, etc. all complete as per specifications, manufacturer's recommendation, drawings and as directed by Enigneer-in-charge. Cost shall also include conduting tests like ultimate tensile strength, elongation and puncture resistance, thickness etc. in laboraties like IITs, ICT or Government approved/ NABL accredited labs, preparation of detailed scheme including layout of water stop arragement, compartmentalisation etc. all complete as per specifications, drawings and direction of engineer in charge. The laying of membrane shall be got done through the authorised applicator of the manufacturer of membrane. The testing of material shall be done from authorised lab same shall be furnished before execution of work,as directed by engineer in charge. Performance Guarantee should be given by the manufacturer after completion of the water proofing work for 10 years for material and workmanship. (Measurement shall be of the concrete surface area covered by water proofing membrane). **The Contractor shall make periodical inspection and repair the waterproofing for any apparent defects to ensure complete waterproofing during the guarantee period. The Contractor shall submit a bank guarantee from a scheduled commercial bank (other than co-operative bank) for an amount of 10% of the cost of water proofing works carried out. The bank Guarantee shall be valid for a period of ten (10) years from the date of acceptance of the water proofing work by NPCIL.**	SQM	1000	3.080501	-	-

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ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
C518	**Providing and laying one layer of minimum 1.5mm thick self adhesive rubber/ bitumen with cross laminated high density polyethylene waterproof membrane (SBS membrane)** for horizontal and vertical surfaces of underground structures i.e. basement, sumps, pits, tunnerls, trenches etc. from the junction of HDPE membrane at bottom and upto 250mm above desired level, including preparing the concrete surface, application of primer, fixing overlaps, mimimum lapping 150mm between HDPE & SBS membrane, protection board of 8mm HDPE dimple board having minimum density of 85 kg/ m3 & hardness 20 (Shore-A), single side HDPE tape, mortar fillet of 50X50 mm, cementitious grout at vertical overlapping, aluminium flashing & fitting, filling the top gap with poly-sulphide sealant conforming to IS 12118 etc. all complete as per specifications, manufacturer's recommendation, drawings and as directed by the Engineer. Cost shall also include conduting tests like ultimate tensile strength, elongation and puncture resistance, thickness etc. in laboraties like IITs, ICT or Government approved/ NABL accredited labs, preparation of detailed scheme including layout of water stop arragement, compartmentalisation etc. all complete as per specifications, drawings and direction of engineer in charge. The laying of membrane shall be got done through the authorised applicator of the manufacturer of membrane. The testing of material shall be done from authorised lab same shall be furnished before execution of work,as directed by engineer in charge. Performance Guarantee should be given by the manufacturer after completion of the water proofing work for 10 years for material and workmanship. (Measurement shall be of the concrete surface area covered by water proofing membrane). **The Contractor shall make periodical inspection and repair the waterproofing for any apparent defects to ensure complete waterproofing during the guarantee period. The Contractor shall submit a bank guarantee from a scheduled commercial bank (other than co-operative bank) for an amount of 10% of the cost of water proofing works carried out. The bank Guarantee shall be valid for a period of ten (10) years from the date of acceptance of the water proofing work by NPCIL.**	SQM	1400	3.198982	-	-
A519	Providing and laying minimum **50mm thick screed concrete of M20 grade** with maximum size of aggregate of 10 mm over layer of Geotextile on horizontal surfaces to protect the water proofing membrane complete as per drawing, specification and direction of Engineer. **(RMC concrete will be supplied by BHEL's RMC agency and issued to contractor as Free of Cost (FOC) Item)**	SQM	2200	0.245738	-	-
A520	Providing and fixing **25 mm thick expanded polystrene protective board** over layer of Geotextile on vertical surfaces to protect the water proofing membrane complete as per drawing, specification and direction of Engineer.	SQM	2100	1.483204	-	-
A522	Providing and laying water proofing treatment for wet areas like toilets, kitchen, pantry of sunken slab etc. with polymer based water proofing material like tapecrete ,cico or equivalent all complete with water ponding test as per IS Code and as directed by engineer in charge.	SQM	100	2.843539	-	-
A523	Providing and laying foam concrete blocks in the toilets,pantry,kitchen/ sunken slab etc. complete as directed by engineer in charge.	CUM	10	29.747458	-	-
A524	Providing and laying an angular fillet around parapet wall junction at roof level of min. 50mm x 50mm, shall be trowel applied in cement-sand mortar including cement, sand mortar in 1:3 proportion, latex based bonding agent (10% by weight of cement), insertion of glass cloth while the angle fillet construction etc all complete. **(Cmenet will be supplied by BHEL and issued as F.O.C. Item)**	RM	400	1.338394	-	-
600	**JOINTS AND FILLERS: Joints & fillers including all labour, material, equipment, transportation, handling, preparation of work procedure & inspection and test plan, submission of reports and getting approval etc at all level as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).**				-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

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WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
601	Supplying & installation of bitumen impregnated fibre board confirming to IS 1838 as joint filler at joints in concrete including nailing, coating of both faces with coal tar pitch/ bitumin etc. all complete.				-	-
a	12 mm wide joints.	SQM	100	2.496873	-	-
b	20 mm wide joints.	SQM	100	3.299910	-	-
c	25 mm wide joints	SQM	100	4.989358	-	-
d	50 mm wide joints	SQM	100	9.987493	-	-
602	Supplying and installation of Dura board HD100 or its equivalent as approved by the Engineer, as filler material in joints including nailing, installation as per manufacturer's recommendation etc. all complete.				-	-
a	12 mm wide joints.	SQM	100	2.729447	-	-
b	20 mm wide joints.	SQM	100	4.581258	-	-
c	25 mm wide joints	SQM	100	4.748008	-	-
d	50 mm wide joints	SQM	100	9.833907	-	-
A604	Supplying and filling in position **caulking/ sealing compounds of approved make** in trapezoidal or triangular groove or any other shape of all sizes at expansion joints, around embedded parts, penetrations and construction joints at various locations including cleaning, surface preparation, mixing, heating, pouring/ injecting in gaps in joints, primer, testing etc. all complete as per specification and direction of engineer in charge. **Payment shall be made as per consumption of polysulphie caulking compound/ epoxy quartz sand caulking compound/ bituminuous sealing compound.**				-	-
a	Polysulphide caulking compound	Kg	400	2.887421	-	-
b	Epoxy quartz sand caulking compound	Kg	400	1.957127	-	-
c	Bituminuous sealing compound (bitumen-polymer cold mastic)	Kg	400	0.921517	-	-
A605	Supplying and installation of high density expanded polystyrene board of minimum density 35 Kg/ cum conforming to IS:4671 wrapped in 250 micron thickness polythene sheets conforming to IS:5210 in floors, walls and all forms of structures including surface preparation, adhesive etc. all complete as per specification and direction of engineer in charge.				-	-
a)	25 mm thick	SQM	50	2.685565	-	-
b)	50 mm thick	SQM	50	3.861597	-	-
c)	75 mm thick	SQM	10	5.546657	-	-
d)	100 mm thick	SQM	10	7.481843	-	-
e)	150 mm thick	SQM	10	9.816354	-	-
B605	Supplying and installation of high density expanded polystyrene board of minimum density 35 Kg/ cum conforming to IS:4671 wrapped in 500 micron thickness polythene sheets conforming to IS:5210 in floors, walls and all forms of structures including surface preparation, adhesive etc. all complete as per specification and direction of engineer in charge.				-	-
a)	25 mm thick	SQM	50	2.270882	-	-
b)	50 mm thick	SQM	50	3.356956	-	-
c)	75 mm thick	SQM	10	4.837966	-	-
d)	100 mm thick	SQM	10	6.812646	-	-
e)	150 mm thick	SQM	10	9.379730	-	-
A610	Providing and fixing PVC water stops (with or without centre bulb) of approved make including making all types of joints by fusing or welding to establish continuity between segments of the water stop and between water stop and embedded parts by splicing, pvc fix cap, testing of joint and DPT for 100% weld length etc. all complete as per specification and direction of engineer in charge.				-	-
a)	150 mm wide and 8 mm thick	RM	800	2.593413	-	-
b)	230 mm wide and 8 mm thick	RM	1200	3.304298	-	-
A611	Providing, fabricating and fixing **MS metallic water stop** of 3.15 mm thickness conforming to IS 2062 galvanised for dry film thickness of 60-100 micron thickness at all type of joints including bending to form V-notch, brazing, lap welding, testing of joint and DPT for 100% weld length etc. all complete as per specification and direction of engineer in charge.	SQM	200	21.901396	-	-
612	Providing and applying approved fire retardant sealant in joints/ openings including cleaning of joints/ openings, raking out groove, application of primer, scaffolding etc. all complete.				-	-
a	25mmX25mm	RM	400	3.743116	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
b	50mmX25mm	RM	400	6.555938	-	-
A616	Providing, fabrication and erection of minimum 22 gauge GI sheets for expansion joints including drilling of holes in RCC / masonry with taper nut type anchor bolts of size M6 x 50 mm at 650 mm c/c, caulking with polysulphide compound between sheet and concrete / masonry surface etc. complete as per specification, drawing and as directed by the Engineer.	SQM	50	8.706145	-	-
615	Providing and fixing 300 mm wide Stainless steel strips over expansion joints with minimum lap of 50mm length including stainless steel screws, rawl plugs etc. all complete.	Kg	100	3.172653	-	-
A617	Providing and filling hydro-swelling polymeric paste of 1.5kg/ litre mix density including making/ cutting 20 mm square groove at top of concrete around pipe sleeve etc. all complete as per manufacturer's specification, specficification and direction of the Engineer in charge. **(Payment shall be made as per consumption of hydro-swelling polymeric paste).**	Litre	50	4.739232	-	-
A618	Providing and fixing 250 micron thick polyethelene sheets conforming to IS 2508 for separation joints as per specification, drawings and as directed by the Engineer in charge.	SQM	100	0.368607	-	-
A619	Providing and fixing the following for sealing of expansion joint including fixing using M6 x 30 mm long bolt @ 300mm c/c through the hole of 7.5 mm diameter etc. all complete as per drawings, specifications and direction of the Engineer in charge. .				-	-
a)	3mm thick L shape continuous copper sheet bent to a radius of 25 mm and sealing with polysulphide seelant at both ends.	SQM	100	5.660749	-	-
b)	8 mm thick x 75 mm wide continuous Neoprene sheet on both vertical and horizontal surfaces between EP and copper sheet.	RM	200	3.773833	-	-
c)	10 mm thick x 90 mm wide continuous MS plate on both vertical and horizontal surfaces over copper sheet.	RM	200	6.933321	-	-
700	**MS EMBEDMENTS: Embedments including all labour, material (unless otherwise specified in BOQ/ contract specification), equipment, transportation, handling, preparation of work procedure, inspection and test plan, submission of reports and getting approval, testing etc. at all level as per specification, drawings and as directed by engineer- in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge)**				-	-
A701	Supply, fabricating and fixing of **mild steel/ carbon steel** embedments, inserts, pipe sleeves, angle pieces, rungs of various diameters, plates of dimensions as required etc. including welding, testing, bolting, cutting, drilling, scaffolding, setting, **connection design & preparation of fabrication drgs, appointment of a seperate independant agency, approved by BHEL, for review and approval of fabrication drgs, in consultation with BHEL** etc. all complete as per specification and direction of engineer in charge.	MT	60	543.686459	-	-
B701	Same as above Item No. A701 with BHEL supllied material free of cost and including loading, transportation, unloading etc. all complete from BHEL store to plant site.	MT	20	170.812456	-	-
A702	Supply, Fabrication, transportation, delivery at site and erection, installation and alignment of mild steel foundation bolt assembly conforming to IS:2062 and grade 1 of IS:432 in concrete along with nuts, lock nuts (as per IS:1363, 1364 and IS:3138), washers, anchor plates, stiffner plates, protective tape, pipe sleeves, templates etc. including welding, testing, cutting, grinding, threading, drilling etc. all complete as per specification and direction of engineer in charge.	MT	2	585.492630	-	-
B702	Extra over **ST NO. A701, B701 and A702** for **shot / grit blasting** of steel surfaces to white metal (Sa 2 1/ 2) and applying **one or more coat of zinc silicate primer** with minimum total DFT of 80 micron of approved make including including touch-up painting etc. all complete as per specification and direction of engineer in charge.	MT of steel	11	24.683500	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

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WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
C702	Extra over **ST NO. A701, B701 and A702 for shot / grit blasting** of steel surfaces to white metal (Sa 2 1/2) and applying **one or more coat of zinc phosphate primer** with minimum total DFT of 80 micron of approved make including including touch-up painting etc. all complete as per specification and direction of engineer in charge.	MT of steel	62	24.486032	-	-
A703	Fixing of embedments, inserts, pipe sleeves, angle pieces, anchor bolts of various diameters, plates of dimensions as required etc. including scaffolding, setting in position, transportation from BHEL site stores to work spot etc. all complete.	MT	10	158.742334	-	-
704	Supplying, fabricating, erecting and installing following items in concrete/ brickwall for all kind of works, including setting material in concrete, layout, scaffoling, cutting, forming, grinding, drilling, bolting, welding, jointing, testing etc. all complete.				-	-
a	MS pipes of all diameters	kg	2000	0.491476	-	-
b	PVC pipes / conduits of all diameters	kg	2000	1.711389	-	-
c	UPVC pipes / conduits of all diameters	kg	2000	2.220418	-	-
d	Expansion anchor fasteners (galvanised) of HILTI make(HRD Universal Fastners) or equivalent of safe tensile capacity as specified below for brick work with expansion sleeve of A6 polyamide:				-	-
i	8mm Dia	EACH	200	0.210633	-	-
ii	10mm Dia	EACH	200	0.254514	-	-
iii	12mm Dia	EACH	200	0.294008	-	-
iv	14mm Dia	EACH	200	0.368607	-	-
e	Expansion fasteners (mechanical galvanised) of HILTI make or equivalent of safe tensile capacity as specified below for concrete work with expansion sleeve of stainless steel:				-	-
i	HST3 M8	EACH	200	0.653838	-	-
ii	HST3 M10	EACH	200	1.004893	-	-
iii	HST3 M12	EACH	200	1.535862	-	-
iv	HST3 M16	EACH	200	2.764552	-	-
v	HST3 M20	EACH	200	5.476446	-	-
vi	HST3 M24	EACH	200	10.430699	-	-
f	Chemical Expansion fasteners (galvanised)of HILTI make or equivalent of safe tensile capacity as specified below for concrete work with anchoring rod,nuts,washers,chemicals all complete,etc:				-	-
i	HAS-E5.8 M8	EACH	200	1.878140	-	-
ii	HAS-E5.8 M10	EACH	200	2.299405	-	-
iii	HAS-E5.8 M12	EACH	200	2.707506	-	-
iv	HAS-E5.8 M16	EACH	200	4.133664	-	-
v	HAS-E5.8 M20	EACH	200	6.740241	-	-
vi	HAS-E5.8 M24	EACH	200	9.061587	-	-
Ag	Seismically qualified Ductile Anchors fasteners of HILTI make or equivalent of safe tensile capacity as specified below for concrete work with anchoring rod,nuts,washers,chemicals all complete,etc:				-	-
i	10 mm dia	EACH	200	1.132150	-	-
ii	12 mm dia	EACH	200	1.509533	-	-
iii	16 mm dia	EACH	200	2.264300	-	-
Ah	Seismically qualified Non-Ductile Anchors fasteners of HILTI make or equivalent of safe tensile capacity as specified below for concrete work with anchoring rod,nuts,washers,chemicals all complete,etc:				-	-
i	10 mm dia	EACH	200	1.360335	-	-
ii	12 mm dia	EACH	200	1.812317	-	-
iii	16 mm dia	EACH	200	2.716282	-	-
iv	20 mm dia	EACH	200	3.396450	-	-
v	24 mm dia	EACH	200	6.033745	-	-
706	Supply and installation of approved 25mm thick vibration damping resilient pads on/ around foundation of vibrating equipment and at other locations all complete.	SQM	100	11.045044	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
800	**GROUTING/ DRY PACK: Grouting including all labour, material (unless otherwise specified in BOQ/ contract specification), equipment, roughening surface, cleaning, ramming, curing, preparation of work procedure, inspection and test plan, submission of reports and getting approval, testing etc. at all level as per drawings, specifications and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge)**				-	-
802	Providing & grouting of pocket holes, pipe sleeves under base plates, machinery, pipe supporting structures etc. with mix 1:1 (1 cement :1 sand) using non shrink admixture etc. all Complete. **(Cement will be supplied by BHEL and issued as F.O.C item)**	CUM	4	85.714278	-	-
803	Providing & grouting of pocket holes, pipe sleeves and under base plate of structural steel work/ machinery/ pipe supporting structures including roughening of surface, cleaning, ramming, curing etc. all complete with mix 1:1:2 (1 cement : 1 coarse sand : 2 aggregate of 6 mm down graded stonechips) using non shrink admixture as per specification, drawing and direction of engineer-in-charge. **(Cost of all material and cleaning the pocket by compressed air shall be in the scope of the contractor).** **(Cement will be supplied by BHEL and issued as F.O.C item)**	CUM	4	93.990381	-	-
804	Providing & grouting of pocket holes, pipe sleeves and under base plates of structural steel work/ machinery/ pipe supporting structures including roughening of surface, cleaning, ramming, curing etc. all complete with **ConbextraGP-1** or equivalent as per specification, drawing and direction of engineer-in-charge. **(Cost of all material and cleaning of the pockets by compressed air shall be in the scope of the contractor).**	CUM	4	300.642841	-	-
805	Providing & grouting of pocket holes, pipe sleeves and under base plates of structural steel work/ machinery/ pipe supporting structures including roughening of surface, cleaning, ramming, curing, etc. all complete with **Conbextra GP-2** or equivalent as per specification, drawing and direction of engineer-in-charge. **(Cost of all material and cleaning of the pockets by compressed air shall be in the scope of the contractor).**	CUM	4	349.487649	-	-
A805	Providing & grouting of pocket holes, pipe sleeves and under base plates of structural steel work/ machinery/ pipe supporting structures including roughening of surface, cleaning by compressed air, ramming, curing, etc. all complete **with non-shrink, high strength, free flow cementitious grout of approved make complying with the requirements of ASTM C348 & C109 that expands in two stages to counteract the plastic as well as the drying shrinkage,** compressive strength of the grout at optimum W/ C ratio shall not be lesser than 55MPa, 65MPa & 75 MPa at 3days, 7days and 28 days respectively etc. all complete as per drawing, specifications and direction of Engineer in charge.	CUM	4	308.050085	-	-
A806	Providing injection grouting with **solvent free, aggregate free, ultra low viscosity free flowing two component (region/ hardner) epoxy injection resins epoxy grout** of approved make through GI nozzle or non-return type nozzle with pressure pump for water retaining concrete structures, underground basement etc. conforming to ASTM C 881-1987 Type I–Grade I Class (B+C) & class F as applicable, epoxy resign constituent of component "A" shall have an epoxy equivalent of 160-275 g/ g mole, including fixing nozzles, drilling of holes, chemical, admixture, curing, cutting of nipple/ nozzles after completing of grouting, making good of the nipple hole with appropriate non-shrink dry pack, water tightness test etc. all complete as per drawing, specifications and direction of Engineer in charge. **Payment shall be made as per the consumption of epoxy grout.**	Kg	1000	5.138556	-	-
A807	Providing injection grouting with **one component of high grade, low viscosity, polyurethane injection resin swelling type hydrophillic compound** of approved make through GI nozzle or non-return type nozzle with pressure pump for water retaining concrete structures, underground basement etc. including fixing nozzles, drilling of holes, chemical, admixture, curing, cutting of nipple/ nozzles after completing of grouting, making good of the nipple hole with appropriate non-shrink dry pack, water tightness test etc. all complete as per drawing, specifications and direction of Engineer in charge. **Payment shall be made as per the consumption of polyurethane based hydrophillic grout.**	Litre	2000	2.962020	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR						
BOQ CUM RATE SCHEDULE						
WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.						
ST NO	**Item Description**	**Unit**	**Quantity**	**Factor (F)**	**Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)**	**Amount = Quantity * Rate**
900	**DOORS & WINDOWS: Doors, windows, ventilators, louvers, roof ventilators, rolling shutters, partitions including all labour, material (unless otherwise specified in BOQ/ contract specification), equipments, transportation, handling, preparation of working drawings, fabrication drawings etc. at all level as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge)**				-	-
A904	Providing and fixing single or double leaf steel door conforming to IS 4351 with or without top removable panels, factory made swing-in / swing-out **45 mm thick hollow galvanised heavy duty MS pressed steel flush doors along with frame, comprising of best quality 18G galvanized mild steel sheets, door frame** using 16G pressed steel, mastic caulking and grouting the frame, reinforcing vertically and horizontally with steel sections spaced not over 150 mm c/ c, door frame made with 45 mmx45mmx6 mm MS angle section, shutter with 43 mm rolled steel channel section framework with stiffners 40 mm x 40 mm x 3 mm MS angle sections spaced not over 450 mm c/ c, insulating with spun mineral wool or polyurethane foam, min 6mm clear sheet glass vision panel of 240 mm x 340mm in each leaf, louvers wherever required, heavy duty SS hinges, thresholds, bottom ties, fittings etc. complete with frame, heavy duty type fixtures and all hardwares such as aldrops, tower bolts, handles, buffers, door stopers, necessary rubber gaskets / seal for achieving air-tightness, all fittings, mortice lock/ cylinder type with handle on both sides of approved make and type etc. as a complete package including one coat of zinc phosphate primer, one coat of rust resisting paint and two coats enamle paint of best quality and approved make etc. all complete as per drawings, door schedules, specifications and as directed by Engineer.	SQM	50	52.908260	-	-
A906	Providing and fixing anodized extruded aluminium doors (single or double shutter) conforming to IS:1948, IS:1949 fabricated from extruded sections of **Jindal,Bhoruka, Hindalco, Indian Aluminium Co. Ltd or equivalent approved make** having minimum 3mm wall thickness as per IS:1285, IS:733 and alumilited, 0.015 mm thickness, satin finished in natural aluminium colour, protective transparent coating, insulated with spun mineral wool insulation for sound deadening, fixed with rawl plugs, expansion fasteners,SS screws / fixing clips necessary filling of gaps at Junctions, at top, bottom & sides with required PVC / neoprene felt for bi-metallic protection, heavy coat of alkali resitant bitimunous paint, zinc chromate primer etc. Glazing shall be double toughened glass of 6mm thickness including snap fit type beading, concealed screws, all hardwares & fixtures of heavy duty type, approved make cylinder type lock with handle on both sides, etc all complete as per specification and direction of engineer in charge. Aluminium section shall be smooth, free of stains, straight, mitred & jointed mechanically wherever required. **(Glazing shall be paid separately).**	SQM	50	39.550647	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
A907	Providing and fixing (single/ double leaf) **fire rated hollow galvanized MS pressed steel flush doors along with frame** of approved make conforming to IS : 3614 (part 1) & tested to IS/ ISO 3008 and shall carry a unique label with certification/ test report number,fire rating embossment, fixed at all elevations, with or without removable panels,with panic bar,panic trim **with following fire rating** using galvanised MS sheets for frames conforming to IS 277, made out of minimum 1.6mm (16 SWG) for both frame and shutter, G.I. sheet (min.zinc coating 120 gsm), and leaves, mineral wool / PUF/ any other fire retardant insulation material filled with required density, mastic caulking and grouting the frame, reinforcing and insulating the shutters with fire retardant material. The door stiles should be interlocked, for pairs of doors integral astragals has to be provided on the meeting stile. Vision lite, vision panel in each leaf using borosilicate fire rated float glass or approved equivalent of size 240 mm x 340 mm or as specified in drawing, on shutter, fixing with clipon arrangement. EPDM smoke seal to be provided along with frame as standard, including heavy duty ball bearing SS 304 hinges,mortise dead lock, thresholds, fittings complete with frame, fittings, fixtures, handles, necessary gaskets, drop seal, smoke seal etc. for air tightness, , provisions for installation of access control devices, mastic cement, cleaning , all hardware as per door schedule, testing of fire proof door as per IS : 3614 (Part 2) including one coat of approved primer and two coats of approved fire resistant/ intumescent paint as necessary all complete as per drawings, specifications and direction of engineer in charge. All the doors shall have provisions for installation of access control devices such that these devices if installed at a later date shall not impair the basic functions of the door as a fire barrier. These provisions shall be in the form of providing a separate steel plate of approved dimensions of the same material as the parent door, fixed to the main door at an approved location.				-	-
a	1 Hour Fire Rating	SQM	50	88.843049	-	-
b	2 Hours Fire Rating	SQM	200	99.769612	-	-
c	3 Hours Fire Rating	SQM	50	115.387137	-	-
B907	Extra over Sl. No. A907 for testing of fire proof doors as per IS:3614 Part-II standards for approved fire rating, for full size door with vision panel and all fittings and fixtures at approved laboratory etc. all complete as per drawings, specfication and direction of engineer in charge.	SQM	50	34.657829	-	-
A909	Providing and fixing **anodised aluminium work** of Jindal, Bhoruka, Hindalco, Indian Aluminium Co. Ltd. or equivalent approved make for door frames, windows, ventillators, partitions, railing, grills, stair case tread nosing, etc with extruded standard tubular and other sections having minimum 3mm wall thickness including all fittings & fixtures and accessories of approved make conforming to IS733 and IS1285, alumilited, 0.015 mm thickness, satin finished in natural aluminium colour, protective transparent coating, fixed with rawl plugs, expansion fasteners, SS screws or with fixing clips, all hardwares & fixtures of heavy duty type, including necessary filling of gaps at junctions, at top, bottom and sides with required PVC/ neoprene felt for bi-mettalic protection, heavy coat of alkali resitant bitimunous paint, zinc chromate primer etc.including aluminium cleat angle, aluminium snap-on-beading for glazing/ panelling with all fittings and fixtures (like tower bolts, handles, door stopper with rubber shoes, 'L' drops, stays, floor springs, hydraulic door closures etc.), CP brass/ stailess steel screws, providing and fixing hinges/ pivots, and making provision for fixing of fitting wherever required including cost of PVC/ neoprene gasket, all complete as per drawing, specification and instructions of engineer in charge. **(Glazing shall be paid seperately)**. **Weight of aluminium section only shall be measured**	Kg	2600	3.795774	-	-
A911	Providing and fixing of door closers as per specification of approved make & quality all complete of following type :				-	-
a	Over head extra heavy duty type hydraulic door closures as per IS3564	Each	50	8.188340	-	-
b	Floor mounted extra heavy duty type Hydraulic door closers as per IS6315	Each	50	20.729752	-	-
912	Providing and fixing pressed steel frames fabricated from 16 gauge M.S sheet mortised, reinforced drilled and tapped for hinges and locks bolts strikes, hold fasts adjustable floor anchors, floor tiles/ weather bars ,paintings etc all complete as per specifications.	Kg	3145	0.921517	-	-

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ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
A913	Providing, designing and fixing in position of approved make rolling shutter made from tested bright cold rolled, annealed M.S. strips not less than 18G thickness, machine rolled at 75mm rolling centres interlocked together through their entire length and jointed together at the end by heavy type end locks mounted on specially designed pipe shaft with brackets, rolling grills with min 6 mm dia rods @35 mm c/c running horizontally flexible connected with vertical link spaced not more than 200 mm c/c, 20G steel hood, side guides and arrangements for inside and outside cylinder type locking with push and pull operation including wire springs, operating chain, grave cast iron reduction gear, bracket plate, top cover, bottom lath coupled to a lock plate fabricated from 3mm thick galvanised steel plate and securely rivetted with stiffening angles (partly coiled and lath/full lath), testing, one coat of zinc phosphate primer & two coats of synthetic enamel paint of approved make, rolling shutter shall be designed to withstand minimum wind pressure of 150 kg/sqm and steel pipe shaft deflection span/360 shall not exceed span/360, etc. all complete as per IS6248 and specification and direction of enigneer in charge of following types:				-	-
a	Hand Operated	SQM	20	26.065776	-	-
b	Mechanically Operated	SQM	150	33.569561	-	-
c	Mechanically and Electrically Operated	SQM	150	53.118893	-	-
d	Extra over St. No. A913 for providing and fixing Wicket Door with handel, lock and other hardware as required all complete as per drawing,specification and direction of enigneer in charge in the rolling shutter.	SQM	70	27.114551	-	-
A914	Supply and Fixing solid core PVC frame with PVC door shutter minimum 30mm thick and shall be factory fabricated made from min.5 mm PVC sheet. PVC Door Frames shall be made from min.50 x 47 mm section and fabricated from 5 mm PVC sheet having density of 600 kg./cum. Frames shall have smooth surface, without any warping or bending in any member. All the parts of the door frame are to be jointed to each other using solvent adhesive conforming to IS 14182. The sheets used for frame and shutters may be in plain colour, printed design or prelam veneer shade as approved sample, including all fitting & fixtures as per specification, drawing and instructions of engineer in charge.	SQM	20	26.706450	-	-
A915	Providing, fixing and fitting of glazing of superior quality from approved manufactures like Modiguard or equivalent having uniform refractive index and free from flaws, streaks, laminations, bubbles, wavy and rainbow formation etc. in steel/aluminium/wooden frames, where ever required, cleaning after fixing including hardware, gaskets, mastic cement, putty, clips, beadings etc. all complete as per specifications, drawings and direction of engineer in charge.				-	-
a	4 mm thick clear sheet glass	SQM	100	5.937205	-	-
b	4 mm thick clear float glass	SQM	100	6.254470	-	-
Aj	One outer 6mm thick tinted heat-reflecting type toughened glass and one inner 6mm thick plain float glass hermetically sealed and seperated by 12 mm thick gap for thermal insulation (only single elevation area to be measured).The glazing to be used in all exterior walls shall be of ,Asahi,Glavebel ,Saint Gobain or equivalent . The glazing to be used should comply to mentioned standards (VLT (Visible Light Transmittance) ≤ 62 %, SHGC/ SF (Solar Heat Gain Coefficient/ Solar Factor) ≤ 0.32 and U- Value 1.2 to 2.5 W/MSq K.The values varies as per detail engineering.The properties of performance glass,colour,specifiation shall be as per detail design values as approved by engineer incharge	SQM	100	19.632708	-	-
An	6 mm thick double toughened glass for effective thermal insulation	SQM	400	11.659389	-	-
Ap	6 mm thick clear float glass	SQM	200	8.258551	-	-
Aq	8 mm thick clear float glass	SQM	20	9.816354	-	-
Ar	10 mm thick clear float glass	SQM	20	11.369769	-	-
916	Supplying and fixing weather stripping of approved make and quality to doors as per instructions of engineer in charge and specification complete.	RM	1600	1.352656	-	-
918	Providing and fixing steel louvered window with ISMC 100 frame all round including verticals with 18G pressed steel louvers, painting etc. all complete.	SQM	400	20.764858	-	-

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WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
A923	Providing & fixing 120 minutes Fire Rated, Fully Glazed non load bearing fixed partition with valid fire test certificate from national or international lab with Partition Frame manufactured from 1.6 mm galvanized steel sheet (zinc coating not less than 120 gm/ sqm) pressed toform a suitable profile & fixed to the supporting construction by means of M 10 X 120 or bigger steel bolts at 150mm from the edges & every500mm c/ c. The frame shall be finished with etch primer for scratch resistance and shall be powder coated of min. 30 micron of approvedshade and color. The glass panels shall be insulated/ uninsulated minimum 11mm thick, 120 minute fire rating and partially insulated (EW120), with 20minute or more full insulation, Non Wired Toughened Glass having a sound reduction of greater than 37dB, light transmission of 85% and compliant to class 2(B)2 category of impact resistance as per EN 12600. The glass should be manufactured in UL & TUV audited Facility andincluding UL-EU Certification. The glass shall be held in position with 1.2mm x 19mm GI clip-on beading, clamped or bolted to the frame profile by 4mm x 35mm steel screws at every 250 mm c/ c and a ceramic tape of cross section of 5mm x 20mm on both sides of the glass. The item shall include intumescent putty and fire resistant acrylic sealants and the total assembly shall satisfy the fire resistance criteria of stability, integrity & radiation control and partial insulation (EW120).All frame shall be finished polyster powder coated to minimum 50microns, of approved colour. Test certificates should be made available for a complete assembly. all complete as per specification. Glazed system shall be tested to IS/ ISO 3009-1 or IS16947: 2019 for integrity & insulation.Shop drawings for the item with all construction and anchoring details along with fire rating test reports shall be got approved from Engineer-in-Charge before execution.	SQM	20	269.346357	-	-
A924	Providing & fixing minimum 29mm thick Hermetically sealed double glass (DGU) consisting of Fire resistant glass of minimum 11mm thick or more, clear, toughened, borosilicate glass,120 minutes fire rated for both integrity & radiation control ,remain transparent under both fireand non fire condition and 6mm thick toughened tinted glass with 7mm gap. The partitions shall be 120 minutes Fire Rated,Fully Glazed non load bearing fixed partition with valid fire test certificate from national or international lab with Partition Frame manufactured from 1.6 mm galvanized steel sheet (zinc coating not less than 120 gm/ sqm) pressed to form a suitable profile to accomodate the glass & fixed to the supporting construction by means of M 10 X 120 or bigger steel bolts at 150 mm from the edges & every 500mm c/ c .The frame shall be finished with etch primer for scratch resistance and shall be powder coated of min. 30 micron of approved shade and color. The glass panels shall be interlayered minimum 11mm thick, 120 minute fire rating and partially insulated (EW120), with 15 minute full insulation, Non Wired Toughened Interlayered or monolithic glass having a sound reduction of greater than 37dB, light transmission of 87% and compliant to class 1(B)1 category of impact resistance as per EN 12600. The glass should be manufactured in UL & TUV audited Facility and including UL-EU Certification. The glass shall be held in position with minimum 1.6 mm G.I Beading, clamped or bolted to the frame profile by 4mm x 35mm steel screws at every 250 mm c/ c and a ceramic tape of cross section of 5mm x 20mm on both sides of the glass. All frame shall be finished polyster powder coated to minimum 50microns, of approved colour. Test certificates should be made available for a complete assembly.The item shall include intumescent putty and fire resistant acrylic sealants and the total assembly shall satisfy the fire resistance criteria of stability, integrity & radiation control and partial insulation (EW120) all complete as per specification. Shop drawings for the item with all construction and anchoring details along with fire rating test reports shall be got approved from Engineer-in-Charge before execution.	SQM	20	132.343056	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
A925	Providing and fixing of fully glazed steel door with 120 minutes fire rating, of integrity and radiation control (EW 120) fabricated with 1.6 mm thick galvanized steel sheet. The door frames are manufactured from 1.6 mm galvanized steel sheet (zinc coating not less than 120 gm/ sqm) pressed to form a profile of 35 mm x 60 mm on the vertical sides and 50 x 60 mm on the horizontal side. The door shutter would have a top rail and side rail 60 mm x 60 mm and a bottom rail of 110 mm x 60 mm. The frame shall be finished with approved fire resistant primer or Powercoating of min. 50 micron as per approved shade.The sections have a special insulating infill.The test is conducted in IFTS as per EN 1634 and EN1363.The insulated glass should be min. 11mm thick or more, clear, toughened, borosilicate glass, 120 min fire rated for both integrity & radiation control (EW 120) Non Wired toughened glass with a light transmission of 85% and sound reduction of 37 dB and manufactured in UL & TUV audited facility and including UL-EU Certification. The glass should be compliant to class 1(B)1 category of Impact Resistance as per EN 12600. The glass should be held in its place with the help of 1.6 mm GI beading and aspecial ceramic tape with cross section of 5 x 20 mm as per the test evidence. The shutters should be fixed to the frame using Dorma SS Ball Bearing Hinges of size 100 mm x 89 mm and 3 mm thickness or equivalent. Beading should be attached using 4 mm x 35 mm SS screws at distance of 75 mm from the edges and 150 mm c/ c henceforth. The door should be fitted with Dorma Mortise Sash lock 952F and door closer TS68 of Dorma make or equivalent. The inactive leaf should be fixed to the frame using 1200mm long tower bolt.all complete as per specification and approved by Engineer incharge.	SQM	20	132.343056	-	-
A926	Providing and fixing 3M privacy film on glass door, partiton etc.as per design and direction all complete as per specification and approved by Engineer incharge.	SQM	20	5.235096	-	-
1000	**CONCRETE BLOCK MASONRY AND BRICKWORK: Concrete block masonry, Brickwork masonry including all labour, material (unless otherwise specified in BOQ/ contract specification), testing, equipment, transportation, handling, scaffolding, etc. at all levels as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).** **(Cement will be supplied by BHEL and issues as F.O.C. item)**				-	-
A1001	Providing brick work in cement mortar 1:4 (1 part cement: 4 parts coarse sand **conforming to IS 2116**) in walls, chambers etc. in thickness varying from 230mm to 460mm at all depths, places and positions **below plinth** including raking out joints, curing, scaffolding etc. complete excluding plastering and painting.				-	-
a	Using **burnt clay bricks** of class designation 7.5 of nominal dimension and conforming to spcifications , IS:1077	CUM	20	31.397413	-	-
B1001	Providing concrete block masonary works consisting of solid concrete blocks having minimum average compressive strength of 5 MPa and minimum density of 1800 kg/ m3, in cement mortar 1:4 **(1 part cement: 4 parts coarse sand conforming to IS 2116)** by volume with blocks manufactured as per IS:2185 (part-1), construction as per IS 2212, at all depths, places and positions **below plinth** including raking out joints, curing, scaffolding etc. complete excluding plastering and painting.	CUM	50	39.296133	-	-
A1002	Providing brick work in cement mortar 1:4 (1 part cement: 4 parts coarse sand conforming to IS 2116) in walls, chambers etc. in thickness 230mm at all heights, places and positions **above plinth** including concrete mullion/ transom, reinforcement anchoring, reinforcement, formwork, raking out joints, curing, scaffolding etc. complete excluding plastering and painting. (Payment of concrete, reinforcement anchoring, reinforcement and formwork shall be made separately)				-	-
a	Using **burnt clay bricks** of class designation 7.5 of nominal dimension and conforming to spcifications , IS:1077	CUM	50	35.544241	-	-

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ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
B1002	Providing concrete block masonary works consisting of solid concrete blocks having minimum average compressive strength of 5 MPa and minimum density of 1800 kg/ m3, in cement mortar 1:4 (1 part cement: 4 parts coarse sand conforming to IS2116) by volume with blocks manufactured as per IS:2185 (part-1), construction as per IS2212, at all heights, places and positions **above plinth** including concrete mullion/ transom, reinforcement anchoring, reinforcement, formwork, raking out joints, curing, scaffolding etc. complete excluding plastering and painting. (Payment of concrete, reinforcement anchoring, reinforcement and formwork shall be made separately)	CUM	1800	46.207513	-	-
A1003	Providing brick work in cement mortar 1:4 (1 part cement: 4 parts coarse sand **conforming to IS 2116**) in partition walls, vertical walls for waterproofing system, chambers etc. in **thickness 115mm** at all heights, places and position above or below plinth/ graded level including providing two nos. 8 mm diameter MS bars at every fourth layer, reinforcement bar securly anchored at ends, raking out joints, curing, scaffolding etc complete excluding plastering and painting as per specification.				-	-
a	Using **burnt clay bricks** of class designation 7.5 of nominal dimension and conforming to spcifications , IS:1077	SQM	100	5.331636	-	-
b	Using **concrete block masonary** works consisting of solid concrete blocks having minimum average compressive strength of 5 MPa and minimum density of 1800 kg/ m3, in cement mortar 1:4 (1 part cement: 4 parts coarse sand conforming to IS2116) by volume with blocks manufactured as per IS:2185 (part-1), construction as per IS2212.	SQM	200	7.306316	-	-
1005	Breaking of existing brick work at all levels including plastering, removing the rubbish up to a distance of 4 km including transportation, loading, unloading etc. all complete as directed by the engineer.	CUM	10	6.248765	-	-
A1005	**Breaking** of existing **concrete block masonry work** at all levels including plastering, removing the rubbish up to a distance of 4 km including transportation, loading, unloading etc. all complete as directed by the engineer.	CUM	30	8.096188	-	-
A1007	Providing and laying fly ash brick pitching 70mm thick using bricks of nominal size of 230x110x70 mm having compressive strength minimum 75Kg/ Sq.cm. conforming to IS:3495 (Part-II) laid over sloped/ flat surfaces of **drains** preparation of the bed by compaction of insitu soil, filling the joints with 1:6 cement mortar and making provision of weep holes with filter media etc. all complete as per requirement and the direction of the Engineer.	SQM	100	3.348180	-	-
A1009	Supply and placing in position mild steel wire fabric of square mesh 25 mm size and wire diameter of 2 mm for encasing of steel sections in **brick**/ **concrete block**/ **concrete** including cutting, bending, fixing etc. complete.	SQM	20	1.430546	-	-
A1010	Filling existing **concrete block wall, brick wall,** partition wall opening at all level including making good the broken edges/ surface with cement mortar 1:4, painting, finishing to match with existing finishing, scaffolding/ supporting at all level, removal of debris upto a lead of 1 km including loading, unloading, transportation etc. all complete.	SQM	20	4.344296	-	-
1011	Providing and filling brick bats in soak pits all complete.	CUM	20	15.797440	-	-
					-	-
1100	**DAMP PROOF COURSE: Damp proof course including all labour, material (unless otherwise specified in BOQ/ contract specification), equipment, transportation, handling, shuttering, centering, curing etc at all level as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).** **(Cement will be supplied by BHEL and issues as F.O.C. item)**				-	-
1101	Providing Damp Proof Course of following thickness with 1:1.5:3 concrete (10mm and down graded aggregate) with 2% of approved admixture of water proofing compound all complete. Two layers of hot bitumen coating 85/ 25 grade as per IS:702 @ 1.7Kg./ sqm shall be applied one before & one after the DPC.				-	-
Aa	50mm thick	SQM	105	1.347171	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

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WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
1200	**PLASTERING: Cement mortar plaster including making grooves wherever required including all labour, material (unless otherwise specified in BOQ/ contract specification), scaffolding, curing etc at all level as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).** **(Cement will be supplied by BHEL and issued as F.O.C. Item)**				-	-
B1201	Providing **20mm thick rough cast/ sand faced plaster** in two coats over **exterior** masonry and concrete surfaces at all heights with 12mm thick base coat and 8mm thick finished coat in cement sand mortar 1:3 with waterproofing compound conforming to IS: 2645 of approved make and manufacturer recommendation, including 3mmx3mm size grooves at junctions of two dissimilar materials, surface preparation, joint preparation, chamfering, hacking of concrete surfaces, scaffolding, curing, tools, labour, rendering etc. all complete as per drawing, specification or as directed by Engineer in charge.	SQM	9200	2.180924	-	-
A1202	Providing 15mm thick plaster to interior masonry / concrete surfaces in cement sand mortar 1:3 at all heights to a smooth finish including surface preparation, joint preparation, chamfering, hacking of concrete surfaces, scaffolding, curing, tools, labour, rendering etc. all complete as per drawing, specification or as directed by Engineer in charge.	SQM	16900	1.680672	-	-
A1204	Providing 6mm thick plaster on ceiling in cement sand mortar 1:3 finished to a smooth all complete.	SQM	8500	1.540250	-	-
A1205	Providing and laying **20 mm** thick **cement sand plaster** (1:3) by volume over concrete / masonry surface of **drains, culverts, tunnel, trenches etc.** complete as per drawing, specification and direction of the Engineer.	SQM	1000	1.619238	-	-
A1206	Providing neat cement finish @ 1kg/ sqm over plastered surfaces and rubbed smooth with trowel etc. all complete as per drawing, specification and direction of the Engineer.	SQM	400	0.495864	-	-
1207	Forming groove of uniform size from 12X12 mm upto 25X15 mm in plastered surface as per approved pattern, using wooden battens nailed to the under layer, including removal of wooden battons, repair of the edges of plaster panel and finishing the groove etc. complete as per specification, drawing and the instructions of engineer in charge.	RM	1000	0.201856	-	-
A1208	Providing and laying encasement to box type steel beams at all levels with lath plaster 50 mm nominal thickness with cement plaster (1:3) over chicken wire mesh including all labour, materials, equipment, handling, transporting, mixing, placing, leveling, curing and cleaning, finishing the exposed surfaces etc including centering and shuttering all complete as per specification, drawing and instructions of enginner in charge (chicken wire mesh to be paid separately)	SQM	40	2.685565	-	-
1209	Ruled pointing in masonry in Cement Mortar 1:3 (1 cement and 3 fine sand) including raking out joints, curing etc. complete.	SQM	40	1.035610	-	-
A1210	Providing **drip coarse** on plastered surface at all elevations for all type of work such as chajjas, parapet, canopy, projections etc over window, doors heads etc including scaffolding, finishing etc. complete with all labour, tools and plants as per specification, drawing and instructions of engineer in charge.	RM	300	0.539746	-	-

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ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
1300	**FINISHES TO CONCRETE / PLASTERED SURFACES: Finishes, painting to concrete, plastered surfaces including all labour, material (unless otherwise specified in BOQ/ contract specification), equipment, surface preparation, F3 surface finish, scaffolding, testing, preparation of work procedure & inspection and test plan, submission of reports and getting approval etc. at all level as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).**				-	-
A1302	Providing and applying two or more coats of single component, **solvated aliphatic acrylic resin based anti-carbonation, anit-corrosive** and waterproof paint of approved make & shade over a coat of approved primer (each coat of protective paint coating shall have minimum 75 micron DFT and total DFT inclusive of primer shall not less than 225 micron) on **external concrete/ plastered surfaces**, including primer, polymer modified cement putty mortar, surface preparation/ cleaning / scrubbing of the surfaces with wire brushes, soft brushes, sand papers, steel sheet scrappers and mechanical grinder etc. for removing all kind of burrs, imperfections, undulations and other such defects existing in the surface, material testing in approved independent laboratories, filling surface imperfections such as holes, dents, cracks by using polymer modified cement putty mortar to achieve smooth and level surface, cleaning of all surfaces surrounding to painted area like window frames & glasses using suitable thinners, detergents, chemical cleaners etc, all complete as per specification, manufacturer's specification, drawing and direction of Engineer in charge.	SQM	7800	2.167760	-	-
1304	Two or more coats of acrylic distemper of approved brand and manufacture to give an even shade including a priming coat with distemper primer complete.	SQM	1500	0.421265	-	-
A1305	Providing and applying two or more coats of **premier quality acrylic plastic emulsion** (water-based acrylic co-polymer emulsion with rutile titanum dioxide, other selected pigments and fungicide) paint conforming to IS:15489 of approved make & shade over a coat of approved primer to **interior concrete/ plaster surfaces**, including primer, white cement & fine sand, surface preparation, cleaning / scrubbing of the surfaces with wire brushes, soft brushes, sand papers, steel sheet scrappers and mechanical grinder etc. for removing all kind of burrs, imperfections, undulations and other such defects existing in the surface, material testing in approved independent laboratories, filling surface imperfections such as holes, dents, cracks by using mixture of white cement & fine sand (in the ratio of 1:3) to achieve plain & even surface, cleaning of all surfaces surrounding to painted area like window frames & glasses using suitable thinners, detergents, chemical cleaners etc. all complete as per specification, manufacturer's specification, drawing and direction of Engineer in charge.	SQM	16000	1.355947	-	-
A1306	Providing and applying two or more coats of **acid and alkali resistant paint** of approved make and shade conforming to IS:9862 of minimum 500 micron DFT over a coat of approved primer on flooring, ceiling, walls and other surfaces at all elevations including primer, preparation of the surface, protecting & cleaning etc. all complete as per **specification, manufacturer's specification, drawing and direction of Engineer in charge.**	SQM	400	1.992233	-	-
A1307	Providing and applying **250 micron DFT epoxy paint (high build slovent free, 3 component i.e base, hardner and pigment) of approved make and shade** over approved primer on concrete/ plastered surfaces of **wall, interior walls, ceiling** etc. **at all elevation** using airless spray equipment including primer, surface preparation, masking of embedded parts, covering of installed equipments, pipe lines, if any, & removal of the same after completion of painting etc., all complete as per drawing, specifications and as directed by the Engineer.	SQM	1000	2.615354	-	-
B1307	Providing and applying **500 micron DFT self-levelling epoxy coating (heavy duty high build solvent free, selfsmoothing, 4 component i.e. base, hardener, filler & pigment material)** of approved make and shade over approved primer on concrete/ plastered surfaces of floors etc. at all elevation using airless spray equipment including primer, surface preparation, masking of embedded parts, covering of installed equipments, pipe lines, if any, & removal of the same after completion of painting etc., all complete as per drawing, specifications and direction of engineer in charge.	SQM	4000	4.493494	-	-

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ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
C1307	Providing and applying **1200 micron DFT self-levelling epoxy coating (heavy duty high build solvent free, selfsmoothing, 4 component i.e. base, hardener, filler & pigment material)** of approved make and shade over approved primer on concrete/ plastered surfaces of floors etc. at all elevation using airless spray equipment including primer, surface preparation, masking of embedded parts, covering of installed equipments, pipe lines, if any, & removal of the same after completion of painting etc., all complete as per drawing, specifications and direction of engineer in charge.	SQM	2000	7.525725	-	-
1309	Two or more coats of fire resistant transparent paint (@3.5 litre per sqm per coat) as per IS 162 on all woodwork over french polish as per IS 348 or flat oil paint as per IS 137 of approved grade and manufacture to give an even shade as per specifications. French polish payment will be made seperately.	SQM	200	2.194089	-	-
1313	Providing and applying resin bonded granular textured finish, for external applications shall consist of crushed stone/ quartz chips of .5 mm to 2.5 mm size and of approved natural color/ shade and bonded with synthetic resins, adhesives and additives altogether in a single pack mix, applied on cured and dried plaster surface with a dry film thickness of minimum 2 mm. The final finish shall have UV resistance, fungus, bacterial resistance properties all complete with grooves filled with poly sulfide sealant of matching color and shade as per specification/ drawing/ approval of engineer in charge.	SQM	200	4.598810	-	-
1315	Providing and applying resin bonded granular textured finish, for internal applications shall consist of crushed stone/ quartz chips of .5 mm to 1.2 mm size and of approved natural color/ shade and bonded with synthetic resins, adhesives and additives altogether in a single pack mix, applied on cured and dried plaster surface with a dry film nominal thickness of 1.2 mm. The final finish shall have UV resistance, fungus, bacterial resistance properties all complete with grooves filled with poly sulfide sealant of matching color and shade as per specification/ drawing/ approval of engineer in charge.	SQM	200	3.861597	-	-
1317	Providing and applying minimum 2 mm thick white cement punning on walls including preparation of surface, staging, etc to achieve a smooth even surface all complete as per specification and as directed by engineer.	SQM	600	0.614345	-	-
A1322	Providing and applying **ammonia wash** for meldew treatment with 7g of copper carbonate dissolved in 80 ml liquor ammonia and diluted to 1 litre with water or 2.5 percent magnesium silica fluoride solution before application of painting on concrete/ plastered surfaces at all elevations including surface prepartion, protecting & cleaning etc. all complete as per specification, drawing and direction of Engineer in charge.	SQM	100	1.404217	-	-
A1323	Providing and applying **solution of muriatic acid in water (1:6 to 1:8) and washed fully with clear water** before application of painting on concrete/ plastered surfaces at all elevations including surface prepartion, removable of efflorescence by scrubbing, protecting & cleaning etc. all complete as per specification, drawing and direction of Engineer in charge.	SQM	100	0.767931	-	-
					-	-
1400	**FLOORING AND SKIRTING: Flooring and skirting at all level including base layer, labour, material (unless otherwise specified in BOQ/ contract specification), equipments, transportation, handling, curing, polishing, testing, preparation of work procedure & inspection and test plan, submission of reports and getting approval etc. at all level as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).** **(Cement will be supplied by BHEL and issued as FOC item)**				-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

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ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
A1401	**Providing** and laying 40 mm thick **vacuum dewatered hardonite flooring** of cement concrete mix **1:1.5:3 (1 cement: 1.5 sand : 3 stone aggregates 10 mm well graded)** with 28 mm thick base coat and 12 mm thick top wearing coat with metallic floor hardner , 1 part metallic hardener mixed dry with 4 part of cement, 6 mm nominal size stone chips shall be added in proportion of 1 part cement (mixed with hardener) to two parts of stone chips, ready mix non-metallic hardner compound @ approximately 6 Kg/ sqm for a thickness of 3 mm surfacing, aluminium joint strips, plasticizer like Plastiment BV 40 or equivalent, vacuum dewatering etc. including cleaning, surface preparation, guide rails, levelling and compacting, draining out excess water, rubbing and polishing etc. all complete. as per drawings, specification and direction of the Engineer.	SQM	9600	3.901090	-	-
B1401	Providing and laying cement skirting and dado with underbed **cement mortar** 1:3 (1 cement : 3 coarse sand) finished with 6 mm thick neat cement paste at all elevations of specified height having 6 mm projection beyond plastering surface and total thickness of minimum 19 mm including preparation of base, curing, rubbing, rounding of junction with 25 mm radius, polishing etc. all complete as per drawings, schedule and specifications and as directed by the Engineer.	SQM	440	2.711894	-	-
A1416	Providing and laying **premium quality non-skid full body vitrified tiles non-porous,homogenous, abrasion resistant, floor tiles of 1st quality** of size 600mm x 600mm of reputed / approved manufacturer varmora,simpolo or equivalent make and shade, conforming to IS: 15622 having minimum thickness of 9 mm in approved pattern **laid in floor** over underbed of 20mm thick cement mortar 1:4 bedding, close jointed & pointed with matching pigmented white cement slurry and finished to levels / slope as required including cutting of tiles, curing, washing, covering of floor tiles with PVC sheet for protection etc all complete as per drawings, specifications and direction of Engineer-in-charge.	SQM	200	7.889944	-	-
B1416	Providing and laying **premium quality non-skid full body vitrified tiles non-porous,homogenous, abrasion resistant, floor tiles of 1st quality vitrified tile** of size 600mm x 600mm of reputed / approved manufacturer varmora, simpolo or equivalent make and shade, conforming to IS: 15622 having minimum thickness of 9 mm in approved pattern laid in **skirting and dado** over underbed of 12 mm thick cement mortar 1:3 (1 cement : 3 coarse sand) and jointed with neat white cement slurry with pigment of matching of the tile including cutting of tiles, curing, washing etc all complete as per drawings, specifications and direction of Engineer-in-charge.	SQM	40	8.157623	-	-
A1417	Providing and laying premium quality mat finish **non-skid ceramic tile flooring** using 6mm thick ceramic tiles floor tiles of 1st quality conforming to IS: 15622 of approved size (minimum 300 mm X 300), make and approved color and design shade laid as per approved pattern over 20mm thick cement mortar 1:4 bedding, close jointed & pointed with matching cement slurry using white cement mixed with pigment, finished to levels / slope or plumb as required including cutting of tiles, curing, acid washing, covering of floor tiles with PVC sheet for protection etc all complete as per drawings, specifications and direction of Engineer-in-charge.	SQM	100	6.472562	-	-
B1417	Providing and laying **premium quality glazed ceramic tiles** of 6mm thickness of approved size (Min 450mmx300mm),400x400mm , shade from reputed / approved manufacturer varmora,simpolo or equivalent make conforming to IS: 15622 in **skirting and dado with approved color and design,projecting 6mm uniformly from adjacent plaster or wall finish with 50 mm wide matching moulded ceramic trims** fixed with average 10 mm thick underbed cement mortar 1:3 (1 cement : 3 coarse sand) and 6 mm thick setting mortar, jointed with white cement slurry with matching pigment, final surface shall be 6 mm beyond the plastering and total thickness including underbed shall not be less than 20 mm, including cutting of tiles, curing, acid washing, covering of tiles with PVC sheet for protection etc all complete as per drawings, specifications and direction of Engineer-in-charge.	SQM	100	6.678807	-	-
1419	Providing and laying granite stone slab of 20mm thickness single piece for wash basin / sink slab / facia of black or approved colour including 20mm underbed of cement mortar 1:3 with cutting,making corners,moulding and opening etc. all complete.	SQM	20	24.600125	-	-
1422	Providing & fixing Acid / Alkali resistant (Chemical resistant) tiles confirming to IS:4457 in flooring/ Dado and shall be laid over bitumastic lining of min 12mm thick (to be laid in layers of 6mm each). The tiles shall be applied with 6mm thick Potassium Silicate bedding mortar as per IS:4441, 4443 & 4832 and including preparation of surface, application of bitumen primer, curing etc. all complete for following thicknesses. The tiles should be abrasion resistant & durable.				-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
a	20mm thick	SQM	40	12.133312	-	-
b	38mm thick	SQM	40	16.565371	-	-
A1422	Providing and laying **acid and alkali resistant** flooring using non absorbing, without stains, non fading **3 mm thick thermo plastic polypropylene glass lining**, two component based pasting compound, pasting mixture on surface and back side of PPG, fibre mat, hardner etc. inlcuding warranty/ guarantee, surface preparation, pasting, applying dead weight with sand bags, fusion welding, laying, as per the manufacturer's recommendation and by specialised agency etc all complete as per drawings, specifications and direction of Engineer-in-charge.	SQM	400	18.566380	-	-
A1423	Providing and laying acid and alkali resistant **dado and skirting** using non absorbing, without stains, non fading **3 mm thick thermo plastic polypropylene glass lining**, two component based pasting compound, pasting mixture on surface and back side of PPG, fibre mat, hardner etc. inlcuding warranty/ guarantee, surface preparation, pasting, applying pressure by jacks on vertical surfaces, fusion welding, laying as per the manufacturer's recommendation and by specialised agency etc all complete as per drawings, specifications and direction of Engineer-in-charge.	SQM	50	20.093466	-	-
A1427	Providing and laying **6 mm thick premium quality mat finish glazed tile flooring** conforming to IS: 15622 of approved size, make and shade with 20 mm thick underbed cement mortar 1:3 (1 cement : 3 coarse sand) and 6 mm thick setting mortar (1 part portland cement:1 part lime putty: 3 part sand), jointed with white cement slurry with matching pigment, finished to levels / slope or plumb as required including cutting of tiles, curing, washing, covering of floor tiles with PVC sheet for protection etc all complete as per drawings, specifications and direction of Engineer-in-charge.	SQM	100	6.871887	-	-
B1427	Providing and laying **6 mm thick premium quality mat finish glazed tile** conforming to IS: 15622 of approved size, make and shade **in skirting and dado** with 10 mm thick underbed cement mortar 1:3 (1 cement : 3 coarse sand) and 6 mm thick setting mortar (1 part portland cement:1 part lime putty: 3 part sand), jointed with white cement slurry with matching pigment, final surface shall be 6 mm beyond the plastering and total thickness including underbed shall not be less than 20 mm, including cutting of tiles, curing, washing, covering of tiles with PVC sheet for protection etc all complete as per drawings, specifications and direction of Engineer-in-charge.	SQM	20	6.937709	-	-
A1428	Providing and laying 3 mm thick **PVC tile flooring** of approved make and shade including preparation of base, laying with approved adhesive, jointing etc. all complete as per drawings, specifications and direction of Engineer-in-charge.	SQM	100	6.713912	-	-
B1428	Providing and laying 3 mm thick **PVC tiles in skirting and dado** of approved make and shade including preparation of base, laying skirting with approved adhesive, jointing etc all complete as per drawings, specifications and direction of Engineer-in-charge.	SQM	50	6.814840	-	-
1430	Providing and fixing dividing strips in joints of cast in situ floorings at various elevations, finishing, all labour, material etc. complete as per drawing, specification and instructions of engineer in charge.				-	-
a	Glass strips 40 mm wide and minimum 6 mm thick.	RM	1000	0.386160	-	-
A1432	Providing **non-skid finish** to concrete surfaces in ramps, external open stair etc. by forming chequered surfaces having 150 mmx 150 mm rules all complete . Payment of concrete shall be made separately in the relevant item of BOQ.	SQM	100	0.680168	-	-
1500	**ROOFING / SIDE CLADDING: Roofing / side cladding work including all labour, material (unless otherwise specified in BOQ/ contract specification), equipment, transportation, handling, scaffolding, laps, hooks, washers, corner pieces, preparation of work procedure & inspection and test plan, submission of reports and getting approval etc. at all level as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).**				-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
A1511	Providing and fixing under deck insulation of 50 mm thick PUF material of density 36 kg/ cubic meter backed with 0.05 mm thick aluminum foil and 24Gx25 mm wire mesh netting fixed to ceiling or wall as the case may be with 100x50x6 slotted mild steel plate welded to M.S. plate inserts embedded at the soffit of the slab at 600 mm c/ c and 14 G steel wire drawn through slots and fixed to wire netting all complete as per specification.	SQM	100	6.024968	-	-
1600	**FALSE CEILING: False ceiling including all labour, material (unless otherwise specified in BOQ/ contract specification), equipment, transportation, handling, suspension system, preparation of fabrication working drawings, preparation of work procedure & inspection and test plan, submission of reports/ drawings and getting approval etc at all level as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).**				-	-
1601	Providing and fixing glass fibre reinforced gypsum plaster board (GRG) ceiling (having gypsum core mixed with glass fibre) system consisting of metal supporting grid system forming panels of specified size, suspended from RCC slab/ structural steel or catwalkway grid above with 4 mm (minimum) galvanised wires (rods) with special height adjustment clips, including preperation of working drawing, providing openings for AC ducts, return air grills, light fixtures etc (but excluding the cost of catwalkway grid) all complete as per drawings, specification and instructions of the engineer.				-	-
a	12 mm thick GRG board with galvanised light gauge steel load bearing supporting GI frame and finished flat (seamless).	SQM	100	5.888935	-	-
b	12 mm thick GRG board in profile (dome ,curved profiled etc.) with galvanised light gauge steel load bearing supporting GI frame and finished smooth (seamless).	SQM	100	8.833402	-	-
A1603	Providing, designing, fixing and laying **permanently colour coated aluminium false ceiling** of approved colour, any shape, of **Hunter Douglas Luxalon 84C or 84R, 150C, 300C or approved equivalent, plain or micro perforated** with corrosion resistant aluminium alloy panels of minimum thickness 0.5mm, closed type including acoustic pads consisting of 25 mm thick glass wool (density 32 kg/ cum) wrapped in glass cloth on top of panels, 4 mm dia enamelled aluminium of satin black colour panel carrier, adjustable suspension steel rods of 4 mm dia with fixing arrangement, including all accessories, fittings, seismic anchoring and isolation, carrier splice, edge cover profile, coner splices, cross "T", additional hangers and height adjustment clips for return air grills, light fixtures, A.C. ducts, etc all complete as per specification, drawing and direction of engineer in charge.	SQM	220	16.345962	-	-
A1607	Providing, designing and Fixing 12mm thick Calcium silicate board of Hilux or equivalent in plan or elevation with aluminium grid, metal suspension system, anchor fastener adjustable hangers etc. including two or more coats of acrylic emulsion paint of approved colour to give an even shade with smooth finish all complete as per architectural design and detail. Metal suspension system as per ASTM C-635 shall be hot dipped M.S galvanized (grade 180 as per is :277) and nominal size of T-section shall be 24 x 38 mm or 24 x 25 mm cross runners. 24mm wide exposed flange surface shall be permanently color coated. Suspension system shall be as per manufaturer's specification.The size of tiles shall be 600 X 600 mm or seamless as per detail design and drawing etc all complete as per specification, drawing and direction of engineer in charge.	SQM	50	10.079645	-	-
A1612	Providing , Design and fixing Aluminium ceiling trap door in the false ceiling matching with false ceilign material with min. 2mm thick powder coated inner and outer aluminum frame, corner fitting plate with stainless steel of 2mm thick fixture are with self-drilling screws and sealing strip of 6mm width and 6mm thick. Hinge operated through Push-lock mechanism.	SQM	20	17.416678	-	-

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ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
1700	**RAIN WATER DOWN TAKE PIPES, DRAINS, SEWERAGE SYSTEM: Rain water down take pipes, drains, sewerage system at all level including all labour, material (unless otherwise specified in BOQ/ contract specification), transportation, 2 coats of approved paint over one primary coat, fixtures, accessories, preparation of work procedure & inspection and test plan, testing, submission of reports/ drawings and getting approval etc. as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).**				-	-
A1706	Providing and fixing down take ultra violet stabilised Un Plasticized Rigid PVC Rain water pipes of approved make conforming to IS:13592 type A including shoes, bends, clamps, all fittings & fixtures, leak testing, jointing the pipe with suitable material in line and level with seal ring conforming to IS:5382/ IS:14735, fixes with holder etc. all complete as per specification.				-	-
a)	160 mm OD	RM	390	10.553568	-	-
b)	110 mm OD	RM	1400	9.061587	-	-
A1709	Providing, fixing and laying in position above ground/ underground works **HDPE pipes for drains works**, conforming to IS:4984, grade PE 100, pressure rating PN 6, including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, jointing conforrming to IS : 7634 (Part-2), cutting and trimming of pipes, all accessories, fittings & fixtures, preparation of bends as per requirement at site, testing, preparation of bed for laying the pipes etc. all complete as per specification, drawing and directed by Engineer-in-charge				-	-
a)	Nominal diameter 160 DN	RM	50	6.950874	-	-
b)	Nominal diameter 200 DN	RM	50	8.649099	-	-
c)	Nominal diameter 300 DN	RM	50	11.413651	-	-
d)	Nominal diameter 400 DN	RM	50	14.217696	-	-
e)	Nominal diameter 500 DN	RM	50	18.956928	-	-
B1709	Providing, fixing and laying in position above ground/ underground works/ under floors **HDPE pipes for drains works**, conforming to IS:14333, grade PE 100, pressure rating PN 12.5, including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, jointing conforrming to IS : 7634 (Part-2), cutting and trimming of pipes, all accessories, fittings & fixtures, preparation of bends as per requirement at site, testing, preparation of bed for laying the pipes etc. all complete as per specification, drawing and directed by Engineer-in-charge				-	-
a)	Nominal diameter 75 DN	RM	50	4.181933	-	-
b)	Nominal diameter 125 DN	RM	50	6.950874	-	-
c)	Nominal diameter 160 DN	RM	50	7.385303	-	-
d)	Nominal diameter 200 DN	RM	50	9.083528	-	-
e)	Nominal diameter 300 DN	RM	50	12.637952	-	-
C1709	Providing, fixing and laying in position under pressure & underground works **HDPE pipes for drains works**, conforming to IS:14333, grade PE 80, pressure rating PN 6 including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, jointing conforrming to IS : 7634 (Part-2), cutting and trimming of pipes, all accessories, fittings & fixtures, preparation of bends as per requirement at site, testing, preparation of bed for laying the pipes etc. all complete as per specification, drawing and directed by Engineer-in-charge				-	-
a)	Nominal diameter 63 DN	RM	50	2.163372	-	-
b)	Nominal diameter 75 DN	RM	50	2.896197	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
c)	Nominal diameter 90 DN	RM	50	3.804550	-	-
d)	Nominal diameter 110 DN	RM	50	5.011299	-	-
e)	Nominal diameter 125 DN	RM	50	6.279483	-	-
f)	Nominal diameter 140 DN	RM	50	7.881167	-	-
g)	Nominal diameter 160 DN	RM	50	8.943106	-	-
h	Nominal diameter 180 DN	RM	50	11.391710	-	-
A1711	Providing, laying and fixing in position underground **double walled corrugated pipe** for drains works, conforming to IS:16098, Part 2, stiffness class SN 8, including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforrming to IS : 7634 (Part-2), cutting and trimming of pipes, all accessories, fittings & fixtures, preparation of bends as per requirement at site, testing, preparation of bed for laying the pipes etc. all complete as per specification, drawing and directed by Engineer-in-charge.				-	-
a)	Nominal diameter 225 DN	RM	50	18.105622	-	-
b)	Nominal diameter 300 DN	RM	50	26.403666	-	-
c)	Nominal diameter 400 DN	RM	50	38.471155	-	-
d)	Nominal diameter 500 DN	RM	50	64.120055	-	-
1800	**MISCELLANEOUS: Miscellaneous works including all labour, material (unless otherwise specified in BOQ/ contract specification), equipment, preparation of work procedure & inspection and test plan, submission of reports/ drawings and getting approval etc. at all level unless otherwise specified as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).** **(Cement will be supplied by BHEL and issued as F.O.C. item).**				-	-
A1801	Providing and Filling in trenches, plinths, area paving and other underground structures with hand packed rubble soling having graded stone aggregate in layers not exceeding 230 mm in thickness including breaking of stone boulders to required sizes, filling voids and interstices filled in solidly by wedging with hard chips small stones, interstices finished with cement sand mortar(1:10) minimum of required thickness and compacting to 85 % of original volume of stone stack for all lifts, compaction with power roller, surface blinding with sand etc. all complete as per specification, drawing and direction of engineer in charge. **Payment shall be made for the measurement of the volume of the compacted fill.**	CUM	50	11.058208	-	-
B1801	Rubble soling shall be laid to the specified thickness closely packed by hand and firmly set with their broadest face downwards. The interstice between adjacent stones shall be wedged with 40 mm to 75 mm stone jelly (25% of soling by volume) and well driven with wooden mallet to ensure a tightly packed layer.After hand picking and wedging, compaction of the soling shall be done throughly with long hammers, thereafter the small interstices shall be blinded with gravel (20% of soling by volume) and compacted with hand roller.	SQM	100	15.534150	-	-
1804	Providing and fixing weep holes in Retaining wall, drains, etc consisting of 100 mm dia HDPE pipe sleeves with single side covering for the pipe mouth with galvanised welded wire fabric of 20 mm sq. opening all complete.	EACH	50	0.842530	-	-
1807	Anti termite chemical treatment of soil with Chlorpyriphos/ Lindane E.C. 20% with 1% concentration conforming to IS:8944 and as per IS6313 all complete. (Plinth area of building at ground floor only shall be measured for payment).	SQM	1500	0.811813	-	-
1808	Laying of earthing mats/ rods including risers, transportation from yard stores, loading, unloading, cutting to length, welding, protective painting of joints etc. all complete as per **specification, drawing and directed by Engineer-in-charge.** (Excavation & Back filling shall be paid separately under respective item of earth work. Earthing mats/ rods shall be supplied by BHEL free of cost.	MT	10	56.927831	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

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ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
1809	Construction of below ground earthing system test pits as per drawing / sketches including concreting, reinforcement, formwork, providing & fixing GI strip etc as per drawing and specification (excavation & backfilling only will be paid under applicable BOQ items).	NO	10	34.390150	-	-
1810	Construction of below ground earthing system test links as per drawing/ sketches including concreting, reinforcement, formwork, providing & fixing GI strip etc as per drawing & specification (excavation & backfilling only will be paid under applicable BOQ items.	NO	10	30.616317	-	-
1811	Construction of below ground earthing system earth electrodes as per drawing and specification. (Excavation and backfilling only will be paid under applicable BOQ items)	NO	10	2.602189	-	-
1812	Construction of below ground earthing system - Earth connection and riser pig tails as per drawing and specification. (Excavation and backfilling only will be paid under applicable BOQ items& steel shall be supplied by BHEL free of cost.)	NO	10	2.189701	-	-
1813	Providing Earthing pit as per drawing with charcoal & salt, GI pipes, GI earth electrodes, GI wire, GI strips, brick chamber with covers including associated earthwork etc. all complete.	NO	10	164.736585	-	-
1814	Construction of below ground earthing system test pits as per drawing/ sketches including brickwork, plaster, concreting, reinforcement, formwork, providing & fixing GI strips/pipes, GI wires, covers etc as per drawing & specification including associated earthwork.	NO	10	117.791858	-	-
A1814	Providing and installation of 50 x 6 mm GS flat ground conductor embedded in concrete.	RM	200	2.273076	-	-
B1814	Providing, fabrication and installation of wall / floor / neutral pads of 200x60x10 mm MS wall / floor / column pads flushing its face fully with wall/ floor surface including welding of pads to MS rod / GS flat and supporting it in the concrete, painting of pads with two coats of approved anti-corrosive paint after welding etc. all complete.	NO	100	1.838647	-	-
1815	Providing and fixing GI rungs in concrete/ brick walls having zinc coating of minimum 900 g/ sqm etc. all complete.	Kg	100	0.596792	-	-
1819	Supply & fixing expanded metal steel sheet conforming to IS:412. Size of mesh shall be 10mmX40mm with strands of 2.5mm width and 1mm thickness to the structural steel for facilitating fireproofing works.	SQM	200	2.101937	-	-
1823	Providing and laying cinder filling in the toilets,etc complete as directed by engineer in charge.	CUM	10	7.964543	-	-
1824	Disposal of scrap steel, scrap wood, broken packing crates, cable scrap, debris and other civil waste, electrical waste materials etc. from project site to a designated place within 5 KM range, with all manpower T & P etc. including loading and unloading as and when directed by BHEL.				-	-
a)	Steel scrap / metal scrap	MT	10	2.549531	-	-
b)	Debris & Other waste materials.	CUM	10	0.478311	-	-
1827	Anti weed chemical treatment of soil with suitable chemical pertaining to the types of weeds found in the vicinity including providing anti-weed/ soil sterlization test certificate, performance guarantee of three years etc. all complete.	SQM	1000	0.017553	-	-
A1842	Providing and fixing in position GI chicken wire mesh of min 22 gauge dia and 25 mm mesh at the junction of steel, RCC, brickworks for plastering, for steel encasement etc. including materials, scaffolding, labour, tools, cutting, bending, fixing etc. all complete as per specification and direction of engineering In charge.	SQM	1000	0.807425	-	-
A1843	Providing and fixing in position fire proof welded wire mesh conforming to IS:1566 of of approved size and pattern in beams, columns and slabs etc. including materials, scaffolding, labour, tools, cutting, bending, fixing etc. complete as per specification and direction of engineering In charge.	MT	2	836.772858	-	-
2100	**WATER SUPPLY: Water supply work including men, material (unless otherwise specified in BOQ/ contract specification), equipment, preparation of work procedure & inspection and test plan, submission of reports/ drawings and getting approval etc. at all level as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).**				-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

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A2101	Providing and fixing premium quality 15 mm dia heavy **duty type chromium plated (CP)** brass screw down **Bib cock** (latest model) easy clean variety on GI lines conforming to IS: 781.	EACH	4	7.174013	-	-
A2102	Providing & fixing heavy quality 15 mm dia heavy **duty type chromium plated (CP)** brass screw down **Stop cock** (latest model) easy clean variety on GI lines conforming to IS: 781.	EACH	4	6.666520	-	-
A2103	Providing and fixing in position best quality gun metal sluice valves of screw down type with cast iron hand-wheel of approved quality including fixtures & fittings etc. all complete for following sizes.				-	-
a	25mm nominal bore.	EACH	4	12.358864	-	-
b	50mm nominal bore.	EACH	4	20.707811	-	-
A2104	Providing and fixing in position and testing **MS galvanised pipes** heavy quality (Red; class 'C') as per IS: 1239 & fittings conforming to IS: 1879 like tees, elbows, collars, unions, nipples, enlargers, reducers, bends, coupling & all other fittings required to complete the work, including **laying under the floors, in walls** where required, exposed surface of pipes to be coated with oil paint/ anticorrsive paint, cutting chase through brick or concrete work and making good after erction of the pipe lines, roof slabs, including all jointing materials like teflon tape, clamps, wooden gutties, screws, cement, sand, testing the pipes with clean water as per the code of practice water supply in building of IS: 2065 etc. all complete				-	-
a	15 mm nominal bore	RM	200	2.008908	-	-
b	20 mm nominal bore	RM	100	2.552603	-	-
c	25 mm nominal bore	RM	50	3.308247	-	-
d	50 mm nominal bore	RM	50	4.578625	-	-
A2105	Providing, laying, jointing, fixing and testing **external work with MS galvanised pipes** heavy quality (Red; class 'C') as per IS: 1239 & fittings conforming to IS: 1879 like tees, elbows, collars, unions, nipples, enlargers, reducers, bends, coupling & all other fittings required to complete the work, including **two coats of oil paint/ anticorrsive paint,** making good after erection of the pipe lines, all jointing materials like teflon tape, clamps, wooden gutties, screws, cement, sand, testing the pipes with clean water as per the code of practice water supply in building of IS: 2065 etc. all complete				-	-
a	15 mm dia	RM	200	1.991794	-	-
b	20 mm dia	RM	100	2.536806	-	-
c	25 mm dia	RM	50	3.292450	-	-
d	50 mm dia	RM	50	4.529916	-	-
A2106	Providing and fixing cut edge **mirror** 6mm thick of overall size 600X450mm especially fabricated with superior glass (of approved quality) with designer acrylic PVC frame of approved colour and make mounted alround with 6mm thick non-water absorbant Acrylic/ PVC material backing fixed with cleats using C.P. brass screws and washers etc. all complete.	EACH	4	8.096188	-	-
A2107	Prviding & fixing 600 x 125 mm sheet **glass shelves** 6 mm thick or equivalent with CP brass brackets and guard rails, fixed to wooden cleat with CP brass screws including all fixtures and fittings etc. all complete.	EACH	4	5.309256	-	-
A2109	Providing & fixing CP brass heavy quality **towel rods** of size 600 x 20mm with a pair of CP brass brackets, wall flanges etc. fixed to wall with CP brass screws, screwed on to rawl plugs including all fixtures and fittings etc all complete.	EACH	4	5.181560	-	-
A2110	Providing and fixing best quality **white glazed vitreous china ware recessed soap tray** of 150 x 76 mm or equivalent of approved make including cutting hole in wall, rectifying the surface and all fixtures and fittings etc. all complete.	EACH	4	3.901968	-	-
2111	Providing and fixing stainless steel / C.P. liquid soap dispenser. Dispenser shall be round and easily revolving with removable threaded nozzle and mounted on C.P. brackets etc all complete.	EACH	4	2.834763	-	-
A2112	Providing and fixing 150 mm x 150 mm or equivalent recess type **toilet roll holder** in white glazed vitreous chinaware including cutting into wall and making good the same etc. all complete.	EACH	4	5.440902	-	-
A2113	Providing & fixing easy clean CP brass **shower rose** including Shower arm 190mm long and wall flange of superior quality with 15 mm inlet of 100 mm dia revolving type etc. all complete.	EACH	4	5.094674	-	-
2114	Providing & fixing in position P.V.C. water tank of Syntex or approved equivalent including making all necessary inlet & outlet pipes, fixture, ball cocks, valves etc all complete for following capacities. GI pipes shall be paid separately under respective items.				-	-
b	1000 litres capacity	EACH	2	78.987201	-	-
c	2000 litres capacity	EACH	2	142.176962	-	-
A2115	Providing and fixing electric operated hand dryer with photo voltaic control.etc all complete..	EACH	2	46.148272	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
A2116	Providing and fixing approved quality CP brass two pronged **coat hooks** fixed to wall / door with CP brass screws and rawl plugs including cutting and making good the wall etc. all complete.	EACH	2	3.878272	-	-
A2117	Providing, hoisting at required level and fixing 25 litres capacity or equivalent stationary type **electric storage water heater** conforming to IS 2082/ IS302 Part-2 Section 21 of approved make including all accessories like brass connector, fusible plug, non-return valve, pressure release valve, thermostat, stop cock for inlet and outlet and all fittings and fixtures etc. all complete.	EACH	2	84.042382	-	-
2200	**SANITARY: Sanitary work including all labour, material (unless otherwise specified in BOQ/ contract specification), equipment, preparation of work procedure & inspection and test plan, submission of reports/ drawings and getting approval etc. at all level as per specification, drawings and as directed by engineer - in - charge.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, design, working drawings and scheme, details of erection methods, safety manual, job hazard analysis, work procedure, quality assurance plan, quality assurance manual, testing methodologies, inspection and testing plan, acceptance criteria for material qualification, construction completion certificate, transfer docket containing necessary documents like test certificate, inspection reports etc. and obtaining approval from BHEL/ NPCIL as per specification and as directed by engineer - in - charge).**				-	-
A2201	Providing and fixing **premium quality glazed vitreous chinaware wash basin** of approved make **and colour** having size 550 mm x 400 mm or equivalent including, one pair of wall bracket of 35mm x 35mm x 5mm M.S. angle painted with two coats of white enamel paint of approved quality and make, 32 mm NB CP brass waste coupling heavy quality with rubber plug and chain, angle valve and PVC connector, 32 mm NB CP casted brass bottle trap with extension piece and wall flange and connected C.P. pipe as approved, 15 mm NB, CP brass pillar tap heavy deluxe type with triangular / roundish knob for hot & cold water and 15 mm NB CP inlet connection with all brass unions and wiped solders joints, one no. central hole C.P. brass basin mixer without popup waste system with 450mm long braided hoses of superior quality as approved., 32mm dia B class G.I. waste pipe (concealed) of required length (from bottle trap to nahani trap) including painting with anti corrosive bituminous paint.etc. all complete.				-	-
a	White	EACH	2	81.931669	-	-
b	Colored	EACH	2	98.690120	-	-
B2201	Providing and fixing **premium quality glazed vitreous chinaware wash basin oval type** of approved **make and colour** having size 560 mm x 450 mm or equivalent including One pair of wall bracket of 35mm x 35mm x 5mm M.S. angle painted with two coats of white enamel paint of approved quality and make., 32 mm NB CP brass waste coupling heavy quality with C.P. grating, rubber plug and chain, angle valve and PVC connector, 32 mm NB CP casted brass bottle trap with extension piece and wall flange and connected C.P. pipe as approved., 15 mm NB, CP brass pillar tap heavy deluxe type with triangular / roundish knob for hot & cold water and 15 mm NB CP inlet connection with all brass unions and wiped solders joints, One no. central hole C.P. brass basin mixer without popup waste system with 450mm long braided hoses of superior quality as approved., 32mm dia B class G.I. waste pipe (concealed) of required length (from bottle trap to nahani trap) including painting with anti corrosive bituminous paint.etc. all complete.				-	-
a	White	EACH	2	101.928595	-	-
b	Colored	EACH	2	113.658195	-	-
A2202	Providing and fixing premium quality glazed **vitreous chinaware laboratory sink** (conforming to IS: 771 Part-2) of bowl size 600mm x 400mm x 200mm with integrated drain board of approved make including all fittings, CI brackets, CP brass chain with rubber plug, angle valve and connector etc. complete with 40 mm CP brass waste fitting and 40 mm CP brass trap with necessary CP brass union, CP brass connecting pipes etc. all complete.	EACH	2	53.325137	-	-
A2203	Providing and fixing premium quality **stainless steel sink** of SS grade 304 glossy finish having size 600 x 400 x 200 mm (24"x18"x8") including GI brackets ,32 mm NB CP brass waste coupling heavy quality with rubber plug and chain, 32 mm NB CP brass bottle trap with extension piece and wall flange,15 mm NB CP brass inlet connection with all brass unions and wiped solders joints and all accessories such as choke stop stainer, outlet pipe upto floor trap etc. as required all complete.	EACH	2	64.519379	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
A2204	Providing and fixing premium quality **European water closet** of approved make, size (710x390x765) comprising of double siphonic pattern coupled water closet with integral 'P' or 'S' trap in white glazed vitreous chinaware, 10 litres capacity PVC slim type single flushing low level flushing cistern (Dual Flush Tank white) with all fittings complete, 15 mm NB heavy quality CP inlet connection pipe with brass unions and wiped solder joints at ends, 15 mm NB screw down easy clean variety heavy quality CP brass angle valves with C.P. flange of superior quality, germfree EWC solid seat cover (white) with C.P. brass hinges and rubber buffers of approved brand, jet spray provision with 1 Meter PVC tube (stainless steel) with 01 nos 15mm dia CP brass angle valve with CP flange as approved, 15 mm NB heavy quality GI pipes and specials for overflow from cistern upto 150 mm above floor level, concealed in wall and terminated with 15 mm NB brass mosquito proof jali etc. all complete.				-	-
a	Floor mounted	EACH	2	85.196473	-	-
b	Wall mounted	EACH	2	94.626667	-	-
A2205	Providing and fixing premium quality **Orissa type water closet** of approved make with 'P' or 'S' trap in vitreous chinaware best quality first grade with or without vent, having size 580mm x 440 mm or equivalent, including 10 liters capacity PVC slim type single flushing low level flushing cistern Dual Flush Tank with all fittings fitted over a pair of CI or MS bracket etc. complete with all specials, fittings such as lead valve loss syphon 15 mm nominal size, 32 mm NB GI flush pipe heavy quality of appropriate length with brass unions at end, wiped solder joints, 15 mm NB GI overflow pipe concealed in wall and brought down to 15 cm above floor level with mosquito proof jali at end as per specification, 15 mm NB heavy type CP brass inlet connection with brass unions and wiped solder joints at ends, 15 mm NB heavy type CP brass screw down angle valve with C.P. brass flange of superior quality on inlet connection, recess concreting using 1:5:10 nominal mix as per site requirements, including all accessories, necessary brackets, supports, fittings, screws, gratings etc. cutting and making good necessary opening chases etc. all complete.	EACH	2	44.263550	-	-
A2206	Providing and fixing premium quality **white vitreous chinaware flat back lipped front urinal** of approximate basin size 465 x 355 x 265 mm of approved make with PVC flushing cistern with all fittings, fitted on CI brackets, standard size galvanised iron flush pipe, waste pipe and CP brass spreaders with brass union, push cocks, specials, connecters & stopcock, CP brass fittings etc. and GI clamps, painting of fittings and brackets, cutting chase and making good the walls etc. all complete.				-	-
a)	One urinal basin with 5 litres automatic or equivalent with PVC flushing cistern.	EACH	4	115.031694	-	-
b)	Two urinal basins with 10 litres automatic or equivalent with PVC flushing cistern.	EACH	4	167.452867	-	-
2208	Providing, laying light duty non pressure NP3 class RCC pipes with collars jointed with stiff mixture of cement mortar 1:2 including testing of joints etc all complete for following.				-	-
a	200mm dia	RM	20	3.115606	-	-
b	300mm dia	RM	20	6.103955	-	-
c	450mm dia	RM	20	11.505802	-	-
d	600mm dia	RM	40	14.156262	-	-
2209	Providing, laying light duty non pressure NP2 class RCC pipes with collars jointed with stiff mixture of cement mortar 1:2 including testing of joints etc complete for following.				-	-
a	150mm dia	RM	20	3.027843	-	-
b	250mm dia	RM	20	4.506659	-	-
c	300mm dia	RM	20	4.748008	-	-
d	450mm dia	RM	20	6.770958	-	-
e	500mm dia	RM	20	7.183447	-	-
2211	Providing and fixing C.I Manhole heavy duty cover of size 600mmx450mm including frame from reputed manufacture etc. all complete.	EACH	4	81.585003	-	-
2212	Providing and fixing circular heavy duty C.I. manhole cover of 600 mm dia with frame etc. all complete.	EACH	4	74.656070	-	-
2213	Providing and fixing square mouth S.W Gully trap grade 'A' complete with CI grating, brick masonry chamber(Clay Brickwork in 1:6 mortar, 12mm plaster in 1:6 mortar & 1:2:4 Cement Concrete) and water tight CI cover with 300x300mm (inside). The weight of cover to be not less than 4.53 Kg and frame to be not less than 2.72 Kg etc all complete for following sizes:				-	-
a	100x100mm P or S Type.	EACH	4	14.669679	-	-
b	150x100mm P or S Type.	EACH	4	16.082672	-	-

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR

BOQ CUM RATE SCHEDULE

WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.

ST NO	Item Description	Unit	Quantity	Factor (F)	Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)	Amount = Quantity * Rate
c	150x150mm P or S Type.	EACH	4	18.017858	-	-
A2213	Providing & fixing in position best quality salt glazed **stone ware Gully trap** with 150 x 150mm square inlet & 100mm NB outlet conforming to IS: 651 including embedding the trap in 1:4:8 cement concrete, 150 x 150mm size grating at top, construction of brick/ concrete block masonry chamber 300 x 300mm (internal dimension) in 230mm thick brick/ concrete block masonry, embedding the trap, plastering with cement mortar 1:4, 20mm thick inside, outside & all exposed faces, finished with a floating coat of neat cement, providing & fixing CI frame and cover weighing not less than 7 Kgs., painting the grating, frame & cover with two coats of approved bitumastic paint etc. all complete.	EACH	10	14.810100	-	-
A2214	Providing and fixing in position deep seal C.I. **floor trap** of self cleaning design 100mm NB inlet and 75 mm NB outlet with C.P. brass hinged grating on top including embedding in cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate of 20 mm nominal size) etc. complete as per drawings, specifications and as directed by Engineer.	EACH	10	5.331636	-	-
A2215	Providing and fixing C.I. floor traps with stainless steel grating etc all complete.	EACH	20	8.293656	-	-
2216	Providing and installing approved brand single tap water cooler of 80 L cooling capacity all complete.	EACH	2	301.270350	-	-
A2218	Providing and fixing premium quality black granite of 18mm thick for **urinal partition** with rounded exposed corners etc. as approved by Engineer (size 600 x 1000 mm or equivalent) including cutting the wall & making good the same after fixing the partitions in approved pattern including fittings and fixtures etc. all complete.	EACH	8	20.014479	-	-
2219	Providing and fixing eye and face drinking water fountain (combined unit with receptacle conforming to IS: 10592) all complete as per specification.	EACH	2	40.279084	-	-
2220	Providing and fixing heavy duty cast iron pipes for above and below ground sanitory works with water tight lead joint, fixing clamps, excavation, filling, disposal etc. all complete for the following.				-	-
a	75mm dia pipes	RM	20	6.433069	-	-
b	100mm dia pipes	RM	20	8.065471	-	-
c	150mm dia pipes	RM	20	13.533140	-	-
d	200mm dia pipes	RM	20	20.018867	-	-
e	250mm dia pipes	RM	20	34.749980	-	-
2221	Providing, laying spun CI pipes with conforming to IS 1536 complete for following.(Excavation,backfilling,concrete to be paid seperately)				-	-
a	75mm dia	RM	20	7.402856	-	-
b	100mm dia	RM	20	10.189349	-	-
c	150mm dia	RM	20	14.406388	-	-
d	200mm dia	RM	20	20.808739	-	-
e	250mm dia	RM	20	28.338853	-	-
f	300mm dia	RM	20	34.640276	-	-
2222	Providing and fixing HDPE pipes in concrete/ brick work of following sizes including cutting, fixing and levelling in position etc. all complete.				-	-
a	Upto 75 mm dia	RM	20	2.259912	-	-
b	100 mm dia	RM	20	3.041007	-	-
c	150 mm dia	RM	40	6.020580	-	-
d	200 mm dia	RM	100	9.693485	-	-
A2225	Providing & fixing CI **Nahani trap** of self cleaning design with 75mm NB outlet having a minimum water seal of 30mm with SS grating on top including necessary 1:1.5:3 cement concrete for embedding the trap and making good the floor connecting trap to the waste pipe forming circular hole upto floor level and rendering smooth etc. all complete.	EACH	10	7.354586	-	-
	TOTAL AMOUNT (Rs.)					₹ -

Note:	
1	Bidder's quoted price above shall be complete in all respect for the full scope defined in specification and in accordance with all terms & conditions of tender.
2	Contractor shall fully understand description and Specifications of items mentioned in BOQ.
3	Conditional price bids with any deviation / clarification etc. are liable to be rejected. No cutting / erasing / over writing shall be done.
4	Quantities mentioned in rate schedules are approximate only and liable for variation on either side depending upon site / design requirement. The tentative contract value (CV) of entire scope of work shall be calculated as per finally quoted / accepted rates & the Quantities indicated in BOQ cum Rate Schedule .

PROJECT : 2X700 MWe GHAVP NPCIL GORAKHPUR						
BOQ CUM RATE SCHEDULE						
WORK: Civil, Structural, Architectural & Other associated works of Electrical bay buildings for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2 at Gorakhpur Haryana.						
ST NO	**Item Description**	**Unit**	**Quantity**	**Factor (F)**	**Rate =Factor(F) * A / 1000000 (rounded off to two place after decimal)**	**Amount = Quantity * Rate**
5	Contractor's total quoted price as per rate schedule will be taken as tentative only. The contractor undertakes to execute actual quantities as per advice of BHEL Engineer and accordingly the final contract price shall be worked out on the basis of quantities actually executed at site and payments will also be regulated for the same.					
6	In case of any mis-match in rate and amount on price discrepency, the same will be dealt as per clause no. 1.4 of GCC.					
7	Taxes (GST) shall be payable extra as per relevant clause in Technical Conditions of Contract.					

1.0 Applicability:

The safety clauses are applicable to Engineering, Procurement and Construction Contracts.

2.0 Safety Guidelines:

2.1 The contractor shall provide and maintain all lights, fencing, guards, warning signs and caution board and similar items as required ensuring safe working conditions at work site.

2.2 The contractor and his sub-contractor shall comply with the instructions given by departmental safety officer or his representative(s) regarding safety precautions, protection measures and housekeeping etc.

2.3 The contractor shall comply with all provisions of "AERB Safety Guide for Works Contract" Document No. AERB/SG/IS-1 and other safety requirements as applicable to specific site. A copy of the guide can be obtained from NPCIL on request.

2.4 The contractor shall provide proper access and working platforms for all place of work as per laid down standards or as advised by Engineer-in-charge or Head-IS&F.

2.5 The contractor shall ensure that all floor openings in his work are guarded/barricaded during the course of work and at the end of each day's work.

2.6 The Contractor shall meet statutory requirements as well as regulatory requirements applicable to the project, in general, and NPCIL in particular, especially the requirements as per Factory Act-1948 (amended in 1987), Atomic Energy factories Rule-1996 (AEFR-1996 or latest version available at the time of work execution), safety guidelines for Job Hazard Analysis (JHA) & AERB notifications on Industrial & Fire safety. The copies of the same can be obtained from NPCIL on request.

2.7 The contractors' safety professionals shall be well aware about Acts, Rules connected with Industrial Safety and practices particularly applicable to the project and to that effect they have to undergo an assessment at the project within 15 days of their placement at the project at the cost of the contractor and then only he/she would be given permanent entry pass to plant and considered in the required strength of the safety professionals.

2.8 Workers in general shall not be deployed at work for more than 10 hrs/day and in no case more than 12 hrs/day.

2.9 All PPE procured and provided to workers shall conform to relevant Indian Standards and should be maintained in healthy condition by suitable storage, maintenance and inspection.

2.10 The contractor shall be held responsible for non-compliance of any of the safety measures, injuries, fatalities and compensation arising out of such situations or accidents, and shall be liable as per the Part-B clauses.

3.0 Employees Safety & Workmen Compensation:

Contractor shall be responsible for safety of all his employees during execution of the contract work. As per Workmen's Compensation Act, 1923 (Amended in 2000), the contractor will ensure the payment of compensation to his employees in case of an accident as early as possible within the time frame permitted by the law of land.

4.0 Safety organization of the contractor

4.1 Every contractor shall have an Industrial safety organization having qualified safety professionals as enumerated below prior to the execution of job at project. The minimum numbers of safety professionals shall be

(i) One graduate engineer having post/advance diploma in Industrial safety – for every 1000 workers or part thereof.

(ii) Two numbers of safety supervisors having diploma in engineering and diploma in Industrial safety or at least 6 years experience should be in each shift for every 1000 workers or part thereof. Additional one supervisor for every 500 workers.

4.2 The above is the minimum requirement of safety professionals. The Head (Industrial Safety and Fire) henceforth be termed as Head-IS&F, of the plant, can ask for more safety professionals depending upon nature of jobs being executed by the contractor.

4.3 Contractor's safety professionals shall technically report to Departmental safety organization under Head-IS&F at plant site. However, administrative control and management of safety in the contract work would be the responsibility of the contractor. A committee consisting of representatives of QA, Training and Industrial Safety Group of Headquarters would carry out the verification of safety professional qualification/competence time to time at site.

4.4 In case contractor fails to employ the required safety professionals, the department may at the cost and risk of the contractor deploy additional/required safety professionals. The cost incurred towards this shall be deducted from contractor's bill at following the rates.

1. Safety Engineer = Rs. 1500/day.
2. Safety Supervisor = Rs. 1000/day.

If the required safety professionals are not employed within a month of date of the observation/inspection the payment to the contractor shall be regulated as per S.No. 1 of Annexure-1 applicable for safety professionals

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5.0 Job Supervision at site

5.1 The contractor must ensure adequate job supervision through educated, qualified and experienced supervisors - at least one supervisor for each hazardous job activity to ensure safety during work execution. Similarly, there should be adequate on-site engineering support ensuring coverage of atleast one experienced engineer for every ten supervisors and part thereof.

5.2 In case, the contractor is unable to arrange required work supervisors and engineers for work technical support, a penalty of Rs 10000/- per month for each vacancy will be levied and such five penalties in a year will attract additional fine on him up to Rs 100000/- apart from the payment he has to make for cost of departmental effort to supplement the requirements as specified at 5.1 above. The decision of the Engineer-in-charge, in regard to the penalty imposed shall be final and binding. However, before imposition of penalty, a fair opportunity of being heard, shall be provided to the contractor.
The payment under this clause would be adjusted in Clause- 10.

6.0 Training requirements

6.1 Every Mega Package Contractor or large contractor must build all necessary infrastructure for imparting induction safety training, mock-up trainings and job specific training at plant site at his cost. The required space will be provided free of cost by NPCIL. The Training matters will be guided by Head, IS&F and will be monitored by Training Superintendents. The training evaluation for its effectiveness, will be assessed by nominee of Training Superintendent, QA and/or Head IS&F. The contractor site-in-charge should arrange induction safety training of four hours duration to all workmen prior to engaging them to work and refresher training on monthly basis covering 20% of the workman in a month with 100% coverage within 6 months. This training should be given with necessary Audio, Visual, Posters aids and as per syllabus approved by NPCIL safety group, under the guidance of Training Superintendent or Head IS&F or his representative. The training should be in the language understandable to workmen. This training shall include mock trials of wearing of helmet, use of safety belt and it's hooking up to an independent lifeline etc. The safety-training instructor must certify the workmen for having understood safety aspects and use of PPEs successfully in mockup trial. To ensure proper understanding of safety instructions and safety training, the contractor shall employ literate (at least able to read safety instructions) workers only.
In exceptional cases of not meeting literacy requirement the workers shall be imparted supplementary training.

6.2 The job supervisors and the engineers will have to undergo detailed safety training of at least three days duration at the plant in safety supervision and accident prevention techniques. This training would at the cost of the contractor and then only he/she would be given permanent entry pass to plant.

6.3 Contractor must note that in case the industrial safety induction training as per 6.2 is not conducted within 3 days his workmen shall not get plant entry pass.

7.0 Requirements and specification of PPEs Tools and Tackles

7.1 Every contractor must keep adequate stock of ISI certified (or of relevant international standards) personal protective equipment (PPE), safe working tools and safe working appliances like platforms and access ladders, guard railing etc. and shall ensure these are used during the job for safe execution of the work. These PPE, Tools and Appliances must

be inspected quarterly. Contractor on demand by NPCIL Authorities shall produce the record of such inspections.

7.2 All implements being used for height work like scaffold, access stairs/ladders, platform, railings etc. should be of ISI marked material meeting requirements of AEFR-1996 and should be certified by contractor safety professional prior to its safe use and to the effect that each implement should have display showing it can be safely used.
If any workman is found using sub-standard or damaged PPE, tools & appliance, or any unsafe condition/practices is observed it will be recorded for regulation of payment under clause-10. The decision of the Engineer-in-charge, in regards to the regulation of payment shall be final and binding.

8.0 Work Practices

8.1 The Pre Job Briefing, prior to taking up the work, will be carried out by contractor Safety Engineer/Supervisor to all workers using plant guidelines. The Contractor shall make arrangements for adequate and qualified supervision using checklists during the execution of jobs. The contractor shall ensure that all his workmen must take safety permit for each high-risk job as per project procedure.
If any hazardous work is found without safety work permit/ JHA/ safe working procedure, it will be recorded for regulation of payment under clause-10. The decision of the Engineer-in-charge, ~~in~~ with regard to the regulation of payment shall be final and binding.

8.2 Contractor working at height of more than 2.5 meter above stable floor or ground floor must acquire height pass as per procedure including the worker's medical fitness certificate by certifying surgeon (having MBBS qualification) and worker's height qualification etc.
If in any height work, the worker is found working without having height pass, it will be recorded for regulation of payment under clause-10. The decision of the Engineer-in-charge, ~~in~~ with regard to regulation of payment shall be final and binding.

8.3 Contractor shall ensure safe movement of man and material as well as vehicles in site premises as per rules/regulations applicable at or issued by plant. In case of violation of the rules/regulation, it will be recorded for regulation of payment under clause-10. The decision of the Engineer-in-charge, with regards to the regulation of payment shall be final and binding.

9.0 Safety Plan

9.1 Contractor at his cost shall perform following tasks for the jobs having high risk as identified by Departmental Safety Group:

(i) Prepare Safe Working Procedures and ensure its implementation in field.
(ii) Carry out Job Hazard Analyses (JHA) and implement in field.
(iii) Based on JHA, the safe working procedures should be modified especially to include checklists as necessary checkpoints for job safety supervision.
(iv) Worker(s) must be trained based on the safe working procedure and explained about DOs & DON'Ts prior to assigning him the job.
(v) The workers must adhere to the safe working procedure for the job.

(vi) Contractor shall ensure that all Tools, Appliances, erecting equipment and their safe use by the contractor work force shall be meeting Indian standards. The contractor must ensure that necessary authorization exist with workmen prior to their deployment on a particular appliance/tool/equipment. The workmen would be required to acquire additional authorization for crane operation, crane signaling, blasting operation, welding and cutting operation, electrical work etc. and then only workmen shall be deployed for such job. He shall maintain all record of tools and equipment for their healthiness and safe use with a copy to departmental safety group.

(vii) Employing of any sub-contractor by the main contractor shall be with concurrence of plant authorities & Engineer-In-Charge as per applicable procedure of the plant. The main contractor shall ensure that all safety requirements/conditions are effectively communicated to and well understood by his sub-contractor. The main contractor should ensure safety training & availabilities of required PPEs and he will be responsible for the safety of the workmen of his sub-contractor.

10 Payments Linked with Safety Performance

10.1 2% of the payment of the value of work order or RA Bills shall be based on **Safety Performance** as per above clauses-4.1, 4.2 & 4.4; 5.2, 6.1 to 6.4; 7.1 to 7.3; 8.2, 8.4and 8.5 during the contract period. The checklist No. NPCIL/04710/Safety/2006/M/Checklist No.2 (attached at Annexure-I) shall be applicable for regulation of 2% safety linked payment which shall be duly certified by the committee consisting of the representative of Head (IS &F), QA and Engineer-in-charge.

10.2 The deduction towards other clauses, e.g. Penalties for serious accidents as defined under clause-11, and workman compensation as defined under ~~in~~ clause-3 of Part-A will be in addition to payments regularized under clause 10.1

11.0 Penalties for Serious Accidents

Following shall be the penalties for each category of serious accident:

(i) For each Serious accident (Loss of man days 21 or more) - Rs. 10,000/-.

(ii) For ~~a~~ each fatality – Rs.10, 00, 000/-

12.0 Safety performance Record

On completion of the contract work, a safety performance certificate of the safety record during the execution of the work will be jointly made by Engineer-in-charge, Head (IS&F) and QA representative and that shall be referred in future contract evaluation. Certificate shall be based on Annexure-I and Serious Accident record.

Annexure – I

NPCIL/04710/Safety/2006/M/Checklist No. 02

Checklist cum Certificate for RA Bill payment based on Safety Performance

Sr. No.	Safety Parameters	Safety Clause	% of Running Account (RA) bill for safety compliance	Actual payable
01.	**Safety Professional** Required nos. of Safety Professional employed as per clause.	4.1, 4.2 & 4.4	0.4%of RA Bill (Max.) 0.0% if requisite no. of Safety Professionals are not posted at site within one month.	
02	**Job Supervision at site** Required nos. of Job Supervisors employed as per clause.	5.2	0.1% of RA Bill (Max.) 0.0% if requisite no. of Job Supervisors are not posted at site within fifteen days.	
03.	**Safety Training** i) Safety training imparted to all employees (100%). ii) Safety training imparted to < 80% of its employees.	6.1 to 6.4	0.4% of RA Bill (Max.) 0.0% of RA Bill	
04.	Use of proper PPEs & tools, Safe working condition/practices.	7.1 to 7.3	0.3% (Max.) of RA Bill 0.0% of RA Bill if more than ten nos. of unsafe conditions/ practices observed.	
05.	**Work Practices** 4.1 Adherence to Pre-job Briefing, JHA, Safety Work Permit & Safe Working Procedure for Hazardous works 4.2 All employees working at height have height pass.	8.2 8.4	0.3% of RA Bill (Max.) 0.0% of RA Bill value for > 5 cases as per condition given in clause 8.2. 0.3% of RA Bill (Max.) 0.0% of RA Bill value for > 5 cases as per condition given in clause 8.4.	
06	Safe movement of man and material as per rule and regulation applicable at the site.	8.5	0.2% of RA Bill (Max.) 0.0% of RA Bill if more than 5 violations were observed in a month as per clause 8.5	

Payment certified by :

Engineeer-in-Charge (Works) QA Representative Head (IS & F)



GOVERNMENT OF INDIA

AERB SAFETY GUIDE

SAFETY GUIDE FOR WORKS CONTRACT

ATOMIC ENERGY REGULATORY BOARD

SAFETY GUIDE

FOR

WORKS CONTRACTS

Government of India
Atomic Energy Regulatory Board
Bombay – 400 095

August 1991

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III

F O R E W O R D

Generally the number of accidents are more during construction phase of a Project. These accidents involve mostly contractor workers. A need for a single document in the form of a guide or a manual defining the work situations during construction phase and the required safety precautions/procedures/equipment to be taken/followed/used was recognized by DAE SRC. In its meeting No. 259 held on 5th February, 1986, a Committee with Shri K.S. Somayaji as the Convenor was constituted to look into the type of accidents occurring during construction phase and also to evolve a guide to contain safety precautions that are required to be taken in the construction activities.

This Sub-Committee's report was discussed by DAE SRC in its meeting No. 271 held on 18th June 1986 but unfortunately could not be finalized. On January 3, 1990, this document was circulated to all the units of DAE and also to members of SARCOP for their comments. Several units and members of SARCOP have given their comments and these comments were further reviewed by another Group in consultation with Shri K.S. Somayaji. This Group eventually finalized the guide in its present form taking note of the comments from all the agencies.

In this guide certain qualitative terms like adequate, minimum, near, suitable, good quality, sufficient, etc. have been used, since it is not possible to quantify them for the varied nature of jobs that are being handled at the construction sites. It is recommended that the Safety Engineer and the concerned Engineer In-Charge may be consulted for their better judgment on meeting the qualitative requirements.

IV

This guide was finally discussed at SARCOP Meeting No. 88 held on 22nd August, 1990 and was approved. Every unit of DAE and its Undertakings are required to use the document as a guide to be followed in the award of works contracts to the contractors for compliance with the safety precautions laid down. It is incumbent that this guide be included as part of the tender document for effective compliance.

SARCOP places on record its appreciation for the interest shown by various agencies and individuals in scrutinizing the draft and sending their comments. SARCOP also places on record its appreciation of the time and effort put in by the Committee and the Group to bring this guide in its final form.

(S.D. Soman)
Chairman, AERB

Bombay
August 1991

SAFETY GUIDE FOR WORKS CONTRACT

1. INTRODUCTION

Many of the works of Department of Atomic Energy at its various sites are executed by the contractors. During these works, contractors personnel are likely to be exposed to different types of hazards. Similarly, unsafe acts of contractors personnel may generate hazards for Departmental staff and/or workmen of other contractors working at the site. Such unsafe acts may also pose danger to the existing installations and even to members of public. This guide is prepared to facilitate safe working during execution of contract works. It is hoped that units of DAE may issue this guide as a part of contract documents while awarding contracts.

2. GENERAL SAFETY PROVISIONS

2.1 The Contractor shall take all safety precautions during the execution of awarded work and shall maintain and leave the site safe at all times. At the end of each working day and at all times when the work is temporarily suspended, he shall ensure that all materials, equipment and facilities will not, cause damage to existing property, personal injury or interfere with the other works of the Project or Station. The Contractor shall comply with all applicable provisions of the safety regulations, clean up programme and other measures that are in force at the site.

2.2 The Contractor shall provide and maintain all lights, guards, fencing, warning signs, caution boards and other safety measures and provide for vigilance as and where necessary or as required by the Engineer-in-charge or by any duly constituted authority for the protection of workers or for the safety of others. The caution boards shall also have appropriate symbols.

2.3 Adequate lighting facilities such as flood lights, hand lights and area lighting shall be provided by the Contractor at the site of work, storage area of materials and equipment and temporary access roads within his working area. The Contractor shall obtain written approval of the Engineer-in-charge to the lighting scheme and place of tapping prior to its installation.

2.4 The Contractor shall plan his operations so as to avoid interference with the other Departmental works, other Contractors or sub-Contractors at the site. In case of any interference, necessary coordination shall be sought by the contractor from the Department for safe and smooth working.

2.5 The Contractor and his sub-contractor, if any shall comply with the instructions given by the Safety Engineer or his authorized nominee regarding safety precautions, protective measures, house keeping requirements, etc. The Safety Engineer with due intimation to Engineer-in-Charge shall have the right to stop the work of the Contractor, if in his opinion proceeding with the work will lead to an unsafe and dangerous condition. Engineer-In-Charge shall get the unsafe condition removed or provide protective equipment at the contractors cost. The contractor can employ his own Safety Engineer or nominate one of his officers for liaison with Departmental Safety Engineer for ensuring compliance of all safety rules. Contractor shall ensure that all his workmen are aware about the nature of risk involved in their work and have adequate training for carrying out their work safely.

2.6 The contractor shall be held responsible for non-compliance of any of the safety measures and delays, implications, injuries, fatalities and compensation arising out of such situations or incidents.

3. TRAFFIC

3.1 The Contractor shall conduct his operations so as to interfere as little as possible with the use of existing roads at or near locations where the work is being performed.

3.2 When interference to traffic is inevitable, notice of such interference shall be given to the Engineer-in-charge well in advance (atleast 48 hours) with the details of start of the work and time required, storage of materials, and details of the proposed methods of providing the required facilities for safe and continuous use of roads and obtain his clearance.

3.3 The Contractor shall, at his own expense, make such approved temporary provisions as are required to maintain atleast one lane of traffic by bridging the excavation, providing ramps over surface obstructions or providing suitable temporary bye-pass around the obstructions. The Contractor shall exercise full care to ensure that no damage is caused by him or his workmen, during the operation, to the existing water supply, sewerages, power or telecommunication lines or any other services or works. The Contractor shall be required to provide and erect before construction, substantial barricades, guard-rails, and warning signs. He shall furnish, place and maintain adequate warning lights, signals, etc., as required by Engineer-in-charge.

4. SAFE MEANS OF ACCESS

4.1 Adequate and safe means of access and exit shall be provided for all work places, at all elevations. Using of scaffolding members (avoiding a ladder) for approach to high elevations shall not be permitted.

4.2 Suitable scaffolds shall be provided for workmen for all works that cannot safely be done from the ground, or from solid construction except such short duration work as can be done safely from ladders. Ladder shall be of rigid construction having sufficient strength for the intended loads and made either of good quality wood or metal and all ladders shall be maintained well for safe working condition. An extra mazdoor shall be engaged for holding the ladder if ladder is not securely fixed. If the ladder is used for carrying materials as well, suitable foot holds and hand holds shall be provided on the ladder. The ladder shall be given an inclination not steeper than 1 in 4 (1 horizontal and 4 vertical). Ladders shall not be used for climbing carrying materials in hands. While climbing both the hands shall be free.

4.3 Scaffolding or staging more than 3.5 m above the ground or floor, swung or suspended from an overhead support or erected with stationary support shall have a standard guard rail properly attached, bolted, braced or otherwise secured at least 1.0 m high above the floor or platform of such scaffolding or staging. The guard rail shall extend along the entire exposed length of the scaffolding with only such opening as may be necessary for the delivery of materials. Standard railing shall have posts not more than 2 m apart and an intermediate rail halfway between the floor or platform of the scaffolding and the top rail. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the building or structure. Scaffolding and ladder shall conform to relevant IS specification (IS 3696-1966). Timber/Bamboo scaffolding shall not be used.

4.4 Working platforms of scaffolds shall have toe boards atleast 15 cm in height to prevent materials from falling down.

4.5 A sketch of the scaffolding proposed to be used shall be prepared and approval of the Engineer-in-charge obtained prior to start of erection of scaffolding. All scaffolds shall be examined by Engineer-In-Charge before use.

4.6 Working platform, gangways and stairways shall be so constructed that they shall not sag unduly or unequally and if the height of the platform or gangway or stairway is more than 3.5 m above ground level or floor level, they shall be closely boarded, shall have adequate width for easy

movement of persons and materials and shall be suitably guarded as described in 3.3 above.

4.7 The planks used for working platform shall not project beyond the end supports to a distance exceeding four times the thickness of the planks used. The planks shall be rigidly tied at both ends to prevent sliding and slippage. The thickness of the planks shall be adequate to take load of men and materials and shall not collapse.

4.8 Every opening in the floor of a building or in a working platform shall be provided with suitable means to prevent fall of persons or materials by providing suitable fencing or railing, the minimum height of which shall be 1.0 m, along with 15 cm high sheet obstruction at floor level along the railing.

4.9 Safe means of access shall be provided to all working platforms and other elevated working places. Every ladder shall be securely fixed. No single portable ladder shall be over 9 m in length. For ladders upto 3m in length the width between side rails in the ladder shall in no case be less than 300 mm. For longer ladders this width shall be increased by atleast 20 mm for each additional meter of length. Step spacing shall be uniform and shall not exceed 300 mm.

4.10 Adequate precautions shall be taken to prevent danger from electrical lines and equipment. No scaffolding, ladder, working platform, gangway runs, etc. shall exist within 3 meters of any uninsulated electric wire. Whenever electric power and lighting cables are required to run through (pass on) the scaffolding or electrical equipments are used, such scaffolding structures shall have minimum two earth connections with earth continuity conforming to IS Code of Practice.

5. EXCAVATION, TRENCHING AND EARTH REMOVAL

5.1 All trenches 1.2 m or more in depth shall at all times be supplied with at least one ladder for each spacing of 30 m in length or fraction thereof. Ladder shall be extended from bottom of the trench to at least 1 m above the surface of the ground.

5.2 The sides of the trench which are 1.2 m or more in depth shall be stepped back to give suitable slope (angle of repose) or securely held by timber bracing, so as to avoid the danger of sides from collapsing. The excavated material shall not be placed within 1.5 m of the edges of the trench or half of the depth of the trench, whichever is more. Cutting shall be done from top to bottom. Under no circumstances mining or under-cutting shall be done.

5.3 The contractor shall ensure the stability and safety of the excavation, adjacent structures, services and the works.

5.4 Open excavations shall be fenced off by suitable railing and warning signals installed at night at well lit places so as to prevent slipping or falling into the excavations.

5.5 All blasting operations shall be carried out on the basis of procedures approved by Inspector of Explosives. All works in this connection shall be carried out as per IS Code of Practice. Barricades, Warning Signs etc. shall be placed on the roads/open area. Prior approval of such operation shall be obtained from Safety Engineer/Engineer-In-Charge of works.

5.6 a) For removal of earth from an earth mound a written permission shall be obtained from the Engineer-In-Charge of the work and the Engineer-In-Charge of the earth mound.

b) As far as practical, earth shall be removed mechanically.

c) Wherever manual removal of earth is involved, earth shall be removed from the top by maintaining the proper slope equal to the angle of re-pose of the earth.

d) Such work shall be constantly supervised by the contractor's responsible person and frequently inspected by the departmental representative to ensure that no under-cutting is done.

6. CONCRETING

Shuttering and supporting structures shall be of adequate strength and approved by Engineer-In-Charge. This shall be ensured before concrete is poured. The procedure approved by Engineer-In-Charge shall be followed for mixing, transporting and pouring of concrete.

7. DEMOLITION

Before any demolition work is commenced and also during the progress of the work:

(a) All roads and open area adjacent to the work site shall either be closed or suitably protected. Appropriate warning signs shall be displayed for cautioning approaching persons.

(b) Before demolition operations begin, the Contractor shall ensure that the power on all electric service lines is shut off and the lines cut or disconnected at or outside the demolition site. If it is necessary to

maintain electric power during demolition operation, the required service lines shall be adequately protected against damage. Persons handling heavy materials/equipments shall wear safety shoes.

(c) No floor, roof or other part of the building shall be overloaded with debris or materials as to render it unsafe.

(d) Entries to the demolition area shall be restricted to authorized persons only.

8. PERSONAL PROTECTIVE EQUIPMENT

All necessary personal protective equipment as considered necessary by the Engineer-In-Charge shall be kept available by contractor for the use of the persons employed on the site and maintained in a condition suitable for immediate use. Also the Contractor shall take adequate steps to ensure proper use of equipment by those concerned. The personal protective equipments are to be provided by the contractor.

(a) All persons employed at the construction site shall use safety helmets. For other types of works, persons working in that area shall also use safety helmets, if advised by Safety Engineer/Engineer-In-Charge.

(b) Workers employed on mixing asphaltic materials, cement and lime mortars shall use protective goggles, protective foot wear and hand gloves. Use of proper respirators shall be an advantage.

(c) Persons engaged in welding and gas cutting works shall use suitable welding face shields. The persons who assist the welders shall use suitable goggles. Protective goggles shall be worn while chipping and grinding.

(d) Stone breakers shall use protective goggles. They shall be seated at sufficiently safe intervals of distance.

(e) Persons engaged in or assisting in shot blasting operations and cleaning the blasting chamber shall use suitable gauntlets, overalls, dust-proof goggles, boots and protective hood supplied with fresh air at the minimum rate of 9 m^3 /hr.

(f) All persons working at heights more than 4.5 m above ground or floor and exposed to risk of falling down shall use safety belts, unless otherwise protected by cages, guard railings, etc. In places where the use of safety belts is impractical, suitable net of

adequate strength fastened to substantial supports shall be employed.

(g) All powered two-wheeler motorcycle and scooter drivers an their pillion riders shall wear crash helmets inside the Project/Plant sites.

(h) When workers are employed in sewers and inside manholes which are in use, the Contractor shall ensure that the manholes are opened and are adequately ventilated atleast for an hour. After it has been well-ventilated, the atmosphere inside the space shall be checked for the presence of any toxic gas or oxygen deficiency and recorded in the register before the workers are allowed to get into the manholes. The manholes opened shall be cordoned off with suitable railing and provided with warning signals or caution boards to prevent accidents. There shall be proper illumination in the night.

9. PAINTING

9.1 The Contractor shall not employ women on the work of painting with products containing lead in any form. Only men above the age of 18 years shall be employed on the work with lead paint. The following precautions shall be taken during the work.

* Supplied air respirators shall be provided for use by the workers when paint is applied in the form of spray, or a surface having lead paint is dry rubbed or scraped.

* Overalls shall be supplied by the Contractors to the workmen and adequate facilities shall be provided to enable the painters to wash at the cessation of work.

* All painting jobs, especially those in which lead paints are used shall be kept under industrial hygiene surveillance.

9.2 Smoking, open flames or sources of ignition shall not be allowed in places where paints and other flammable substances are stored, mixed or used. A caution board, with the instructions written in national/regional language, “SMOKING – STRICTLY PROHIBITED” shall be displayed in the vicinity where painting is in progress or where paints are stored. Symbols shall also be used for caution boards.

Suitable fire extinguishers/sand buckets shall be kept available at places where flammable paints are stored, handled or used.

When painting work is done in a closed room or in a confined space, adequate ventilation shall be provided. If adequate ventilation cannot be provided, workers shall wear suitable respirators.

9.3 Epoxy resins and their formulations used for painting shall not be allowed to come in contact with the skin. The workers shall use plastic gloves and/or suitable barrier creams.

Adequate ventilation shall be provided especially when working with hot resin mixes.

Increased personal hygiene shall be practiced to control inadvertent contact with the resin and eliminate its effects.

Workers shall thoroughly wash hands and feet before leaving the work. Work clothes shall be changed and laundered frequently.

10. LIFTING MACHINES AND TACKLES

10.1 Use of lifting machines and tackles including their attachments, anchorage and supports shall conform to the following standards or conditions.

(a) Lifting machines and tackles shall be of good mechanical construction, sound material and adequate strength and free from any defects and shall be kept in good repair and in good working order.

Every rope used in hoisting or lowering materials or as a means of suspension shall be of good quality and adequate strength and free from any defect.

(b) Every crane operator or lifting appliance operator shall be properly qualified. No person under the age of 21 years shall be in charge of any hoisting machine or give signal to operator of such machines.

(c) In case of every lifting machine (and of every chain, ring, hook, shackle, swivel and pulley block used in hoisting or as means of suspension) the safe working load shall be ascertained and clearly marked. In case of a lifting machine having a variable safe working load, each safe working load and the conditions under which it is applicable shall be clearly indicated. No part of any machine or any gear referred to above in this paragraph shall be loaded beyond the safe working load except for the purpose of testing. This shall be approved by the Safety Engineer.

(d) In case of departmental machines, the safe working load shall be notified by the Engineer-in-charge. As regards Contractor's machines, the Contractor shall notify the safe working load of the machine to the Engineer-in-charge whenever he brings any machinery to site of work and get it verified by the Engineer-in-charge, supported by a valid test certificate by the Competent Person.

(e) Thorough inspection and load testing of lifting machines and tackles shall be done by a competent person atleast once every 12 months and records of such inspection and testing shall be maintained.

10.2 Motors, gearing transmission, couplings, belts, chain drives and other moving parts of hoisting appliances shall be provided with adequate safeguards. Hoisting appliances shall be provided with such means as will reduce to the minimum the risk of any part of a suspended load becoming accidentally displaced or lowered.

11. WELDING AND GAS CUTTING

11.1 Welding and gas cutting operations shall be done only by qualified and authorized persons and as per IS specifications and Code of Practice.

11.2 Welding and gas cutting shall not be carried out in places where flammable or combustible materials are kept and where there is danger of explosion due to presence of gaseous mixtures.

11.3 Welding and gas cutting equipment including hoses and cables shall be maintained in good condition.

11.4 Barriers shall be erected to protect other persons from harmful rays from the work. When welding or gas cutting is done in elevated positions, precautions shall be taken to prevent sparks or hot metal falling on persons or flammable materials.

11.5 Suitable type of protective clothing consisting of fire resistant gauntlet gloves, leggings, boots and aprons shall be provided to workers as protection from heat and hot metal splashes. Welding shields with filter glasses of appropriate shade shall be worn as face protection.

11.6 Adequate ventilation shall be provided while welding in confined space or while brazing, cutting or welding zinc, brass, bronze, galvanized or lead coated materials.

11.7 Welding and gas cutting shall not be done on drums, barrels, tanks or other containers unless they have been emptied, cleaned thoroughly and it is made certain that no flammable material is present.

11.8 Fire extinguisher shall be available near the location of welding operations. Fire Safety Permit shall be obtained for working at vulnerable areas and operating areas before flame cutting/welding is taken up.

11.9 For electric (Arc) welding the following additional safety precautions shall be taken :

i) When electrical welding is undertaken near pipe lines carrying flammables, such pipe lines shall not be used as part of earth conductor but a separate earth conductor shall be connected to the machine directly from the job.

ii) Personnel contact with the electrode or other live parts of electric welding equipment shall be avoided.

iii) Extreme caution shall be exercised to prevent accidental contact of electrodes with ground.

iv) The welding cables shall not be allowed to get entangled with power cables. It shall be ensured that the cables are not damaged by movement of materials.

12. GRINDING

12.1. All portable grinders shall be used only with their wheel guards in position to reduce the danger from flying fragments should the wheel break during the use.

12.2. Grinding wheels of specified diameter only shall be used on a grinder – portable or pedestal – in order not to exceed the prescribed peripheral speed.

12.3. Goggles shall be used during grinding operation.

13. ELECTRICTY

Guidelines for providing temporary power supply at the site and general safety procedures for using electricity are given in the enclosed Annexure.

14. HOUSE KEEPING

14.1 The Contractor shall at all times keep his work spot, site office and surroundings clean and tidy from rubbish, scrap, surplus materials and unwanted tools and equipment.

14.2 Welding and other electrical cables shall be so routed as to allow safe traffic by all concerned.

14.3 No materials on any of the sites of work shall be so stacked or placed as to cause danger or inconvenience to any person or the public. The Engineer-in-charge may require the Contractor to remove any materials which are considered to be of danger or cause inconvenience to the public. If necessary, the Engineer-in-charge may cause them to be removed at the Contractor's cost.

14.4 At the completion of the work, the Contractor shall have removed from the work premises all scaffoldings, surplus materials, rubbish and all huts and sanitary arrangements used/installed for his workmen on the site.

14.5 The Engineer-in-charge has the right to stop work if the Contractor fails to improve upon the housekeeping after having been notified.

15. FIRE SAFETY

All necessary precautions shall be taken to prevent outbreak of fires at the construction site. Adequate provisions shall be made to extinguish fires should they still break out.

(a) Quantities of combustible materials like timber, bamboos, coal, paints, etc., shall be the minimum required in order to avoid unnecessary accumulation of combustibles at site.

(b) Containers of paints, thinners and allied materials shall be stored in a separate room which shall be well ventilated and free from excessive heat, sparks, flame or direct rays of the sun. The containers of paint shall be kept covered or properly fitted with lid and shall not be kept open except while using.

(c) Fire extinguishers as approved by the Engineer-in-charge shall be located at the construction site at appropriate places.

(d) Adequate number of Contract workmen shall be given education and training in fire fighting and extinguishing methods.

16. SAFETY WORK PERMIT

16.1 In order to ensure safety of work for hazardous operation (such as entry into confined spaces, welding/cutting on equipment/pipes where explosion hazards is present, works on high voltage and main medium voltage lines, blasting etc.,) special Safety Work Permits (SWP) shall be raised. The SWP's shall also to be obtained for any other work as recommended by Safety Engineer.

16.2 The Contractor shall strictly ensure all the safety conditions and requirements stipulated in the Safety Work Permit. The decision of the Safety Engineer shall be final in this regard.

17. WORK IN RADIATION AREA

The Contractor shall follow the stipulated procedure regarding work in the radiation area and other works related with radiography.

18. WORK IN AND AROUND WATER BODIES

When the work is done near any place where there is risk of drowning, all necessary rescue equipment such as life buoys and life jackets shall be provided and kept ready for use and all necessary steps taken for prompt rescued of any person in danger and adequate provision shall be made for prompt first-aid treatment of all injuries likely to be sustained during the course of the work. Persons who do not know swimming shall not be engaged alone for any work where risk of drowning exists. Sufficient number of life buoys or life jackets shall be provided.

19. MEDICAL FACILITIES

19.1 The Contractor shall arrange adequate facilities for medical aid and treatment for his staff and workers engaged on the work site including the first-aid facilities if they are not available at the Project Site.

19.2 First-aid appliances including sterilized dressing, cotton wool and antiseptic cream shall be made available at a readily accessible places at every work site. These shall be maintained in good order under the charge of a responsible person.

19.3 At large work places where hospital facilities are not available within easy reach of the works, first-aid posts shall be established and be manned by a trained compounder. An ambulance shall be available during the entire period of work for attending to injury cases.

20. SAFETY OFFICER/SAFETY COORDINATOR

The Contractor shall have a Safety Officer or a supervisor to be designated as a Safety Coordinator in order to specifically look into the implementation of different safety requirements of the contract work. The person thus designated will in general co-ordinate with the Engineer-in-charge on matters of safety and in particular ensure that the Safety Guide is complied with fully. His name shall be displayed on the Notice Board at a prominent place at the work site.

21. REPORTING OF ACCIDENT

21.1 All accidents leading to property damage and/or personnel injuries shall be reported to the Engineer-in-charge immediately who shall inform SARCOP to be followed up with detailed accident reports in prescribed form.

21.2 Contractor shall also submit a monthly statement of accidents to Engineer-in-charge by 4th of every month showing details of accident, nature of injury including disability, days lost, treatment required etc., and the extent of property damage.

22. PUBLIC PROTECTION

The Contractor shall make all necessary provisions to protect the public. He shall be bound to bear the expenses for defence of every action or other proceedings at law that may be brought by any person for injury sustained owing to neglect of any precaution required to be taken to protect the public. He shall pay any damage and cost which may be awarded in any such suit, action or proceedings to any such person, or the amount which may be fixed as a compromise by any such person.

23. OTHER STATUTORY PROVISIONS

Notwithstanding the above clauses from 1 to 21 there is nothing in these to exempt the Contractor from the provisions of any other Act or Rules in force in the Republic of India. In particular all operations involving the transport, handling, storage and use of explosives shall be as per the standing instructions and conform with the Indian Explosives Act, 1884 and The xplosives Rules, 1983. Handling, transport, storage and use of compressed gas cylinders and pressure vessels shall conform with the Gas Cylinder Rules 1981 and Static and Mobile Pressure Vessels (Unfired) Rules 1981. In addition, The Indian Electricity Act 1910 and Indian Electricity Rules 1956, the Atomic Energy Act, 1962, the Radiation Protection Rules 1971, Radiation Protection Manual of Nuclear Facilities

and the Atomic Energy (Factories) Rules 1988 and various rules and Act related to mining shall also be strictly complied with.

ANNEXURE

GUIDELINES AND GENERAL PROCEDURES FOR SUPPLY AND USE OF ELECTRICITY AT SITE

1. GENERAL

Following safety requirements shall be complied with before the Contractor uses the power supply.

1.1 The Contractor shall submit a list of licensed electrical staff to be posted at site.

1.2 It shall be the responsibility of the Contractor to provide and maintain complete installation on the load side of the supply point with regard to the safety requirements at site. All cabling and installation shall comply with the appropriate statutory requirements given below and shall be subject to approval of the Departmental Engineer-in-charge/Electrical Engineer.

a) Indian Electricity Act, 1910

b) Electricity (Supply) Act, 1948

c) Indian Electricity Rules, 1956

d) National Electric Code 1985

e) Other relevant rules of Local Bodies and Electricity Boards.

After installation of the electrical power wiring works by the contractor, form of completion certificate as per IS 732 (Form SGCW-1) shall be submitted by the contractor duly signed by the authorized valid licensed electrical contractor and/or supervisor along with one copy of the contractor's license and/or competency certificate of supervisor issued by the Electricity Board/Government Electricity Organization as per the enclosure.

The power supply shall be regulated as per the terms and conditions of the supply of the respective electricity boards.

1.3 (a) For purposes of electrical load and power planning by the electrical section, the contractor shall furnish along with the tender, the estimated load requirement of electric power for the execution of the contract works in terms of maximum Kilo Watt or KVA demand during various periods/months of the contract period along with the details of the construction electrical equipment/machinery with their individual load details and location/locations of power supply

required for availing temporary electric power supply in the standard proforma enclosed (Form SGCW-2).

(b) The electric power supply will be generally made available at one point in the works site of the contractor by the department.

(c) Where distribution boards are located at different places the Contractor shall submit schematic drawing indicating all details like size of wires, Over Head or cable feeders, earthing etc. The position and location of all equipment and switches shall be given.

1.4 The Contractor shall make his own arrangements for main earth electrode and tappings thereof. The existing earth points available at site can be used at the discretion of the Departmental Electrical Engineer with prior permission. Method of earthing, installation and earth testing results shall conform to relevant I.S. Specifications (IS-3043)

1.5 All three phase equipment shall be provided with double earthing. All light fixtures and portable equipment shall be effectively earthed to main earthing.

1.6 All earth terminals shall be visible. No gas pipes and water pipes shall be used for earth connection. Neutral conductor shall not be treated as earth wire.

1.7 The Contractor shall not connect any additional load without prior permission of Departmental Electrical Engineer. For obtaining additional power required, test reports of the tests mentioned in (d) of Form SGCW-1 shall be submitted.

1.8 Joints in earthing conductors shall be avoided. Loop earthing of equipment shall not be allowed. However, tappings from an earth bus may be done.

1.9 The entire installation shall be subjected to the following tests before energisation installation including portable equipment :

a) Insulation resistance test

b) Polarity test of switches

c) Earth continuity test

d) Earth electrode resistance

The test procedures and their results shall conform to relevant IS Specifications. The Contractor shall submit a test report for his complete installation every 2 months or after rectifying any faulty section in the specimen test report. One such test report for the complete installation shall be submitted before onset of monsoon.

2. The following are provided for general guidance of the Contractor and shall be read as specific requirement, in addition to complying with Indian Electricity Act, Indian Electricity Rules and IS Specifications.

2.1 Installation

a) Only persons having valid wireman's license/competency certificate shall be employed for carrying out electrical work and repair of electrical equipment, installation and maintenance at site. The job shall be supervised by a qualified licensed Supervisor.

b) Electrical equipment and installations shall be installed and maintained as to prevent danger from contact with live conductors and to prevent fires originating from electrical causes like short circuits, overheating etc. Installation shall not cause any hindrance to movement of men and materials.

c) Materials for all electrical equipment shall be selected with regard to working voltage, load and working environment. Such equipment shall conform to the relevant standards.

d) The minimum clearance to be maintained for all overhead lines along roads and across roads shall be as per the statutory requirements as listed in clause 1.2 of Annexure.

e) Grounding conductor of wiring system shall be of copper or other corrosion-resistant material. An extra grounding connection shall be made in appliances/equipment where chances of electric shock is high.

f) Electric fuses and/or circuit breakers installed in equipment circuits for short circuit protection shall be of proper rating. It is also recommended that high rupturing capacity (HRC) fuses be used in all circuits. For load of 5 KW or more earth leakage circuit breaker shall be provided in the circuits.

g) Wherever cables or wires are laid on poles, a guard wire of adequate size shall be run along the cables/wires and earthed effectively. Metallic poles as a general rule, shall be avoided and if used shall be earthed individually. Anticlimbing guards and danger

notices shall be provided on poles. Each equipment shall have individual isolating switches.

h) Wires and cables shall be properly supported and an approved method of fixing shall be adopted. Loose hanging of wires & cables shall be avoided. Lighting and power circuits shall be kept distinct and separate.

i) Reinforcement rods or any metallic part of structure shall not be used for supporting wires and cables, fixtures, equipment, earthing etc.

j) All cables and wires shall be adequately protected mechanically against damages. In case the cable is required to be laid under ground, it shall be adequately protected by covering the same with bricks, Plain Cement Concrete (PCC) tile or any other approved means.

k) All armoured cables shall be properly terminated by using suitable cable glands. Multistranded conductor cables shall be connected by using cable lugs/sockets. Cable lugs shall preferably be crimped. They shall be of proper size and shall correspond to the current rating and size of the cable. Twisted connections will not be allowed.

l) All cable glands, armouring and sheathing of electric cables, metal circuits and their fittings, metallic fittings and other non-current carrying parts of electrical equipment and apparatus shall be effectively grounded.

m) All the Distribution Boars, Switch Fuse units, Bus bar chambers, ducts, cubicles etc. shall have MS enclosures and shall be dust, vermin and water proof. The Distribution Boards, switches etc. shall be so fixed that they shall be easily accessible. Changes shall be done only after the approval of the Departmental Electrical Engineer.

n) The Contractor shall provide proper enclosures/covers of approved size and shape for protection of all the switch board, equipment etc. against rain. Exposed live parts of all electrical circuits & equipment shall be enclosed permanently. Crane trolley wires and other conductors which cannot be completely insulated shall be placed such that they are inaccessible under normal working conditions.

o) Iron clad industrial type plug outlets are preferred for additional safety.

p) Open type Distribution Boards shall be placed only in dry and ventilated rooms; they shall not be placed in the vicinity of storage batteries or otherwise exposed to chemical fumes.

q) Isolating switches shall be provided close to equipment for easy disconnection of electrical equipment or conductors from the source of supply when repair or maintenance work has to be done on them.

r) In front of distribution boards a clear space of 90 cm shall be maintained in order to have easy access during an emergency.

s) Adequate working space shall be provided around electrical equipment which require adjustment or examination during operation.

t) As far as possible electrical switches shall be excluded from a place where there is danger of explosion. All electrical equipment such as motors, switches and lighting fittings installed in work room where there is possibility of explosion hazards shall be explosion proof.

u) All connections to lighting fixtures, starters or other power supplies shall be provided with PVC insulated, PVC sheathed twin/three/four core wires to have better mechanical protection for preventing possible damage to equipment or injury to personnel. Taped joints shall not be allowed and the connections may be made in looping system. Electric starter of motors, Switches shall not be mounted on wooden boards. Only sheet steel mounting or iron frame work shall be used.

v) All the lighting fixtures and lamp holders shall be of good quality and in good condition. Badly repaired or broken holders, etc. shall not be used.

w) Only PVC insulated and PVC sheathed wires or armoured PVC insulated and sheathed cables shall be used for external power supply connections of temporary nature. Weather proof rubber wires shall not be used for any temporary power supply connections. Taped joints in the wires shall not be used.

x) The bulbs/lamps used for illumination and testing purpose shall have cover or guard to protect them from accidental breakages.

Only 24 V supply system shall be used for hand lamps etc. while working inside metallic tanks or conducting vessels.

y) After installation of new electric system and or other extensive alterations to existing installations, thorough inspection shall be made by Departmental Electrical Engineer before the new system or new extension is put in use.

z) Contractor shall ensure that power factor for their loads shall be maintained at 0.85. In case the power factor falls below 0.85, necessary capacitor units shall be provided by the contractor.

2.2 Operation & Maintenance

a) All persons who work with electrical installation/equipment shall be aware of the electrical hazards, use of protective devices and safe operational procedures. They shall be given training in fire fighting, first aid and artificial resuscitation techniques.

b) The supervisor shall instruct the workers in the proper procedure, specify and enforce the use of necessary protective equipment such as adequately insulated pliers, screw drivers, fuse pullers, testing lamps and similar hand tools. Only wooden ladders shall be used to reach the heights in electrical work.

c) No material or earth work shall be allowed to be dumped below or in the vicinity of the bare overhead line conductors.

d) Separate work permits shall be issued for individual group leaders working on the same system which shall be returned after the completion of the work to Safety Supervisor and no system shall be energized without the clearance of Safety Supervisor.

e) Before any maintenance work is commenced on electrical installations/equipment, the circuits shall be de-energized and ascertained to be dead by positive test with an approved voltage testing device. Switches shall be tagged or the fuse holders withdrawn before starting the work. Adequate precautions shall be taken in two important aspects viz.

i) That there shall be no danger from any adjacent live parts and

ii) That there shall be no chances of re-energisation of the equipments on which the persons are working.

f) While working on or near a circuit, whenever possible the use of one hand may be practiced even though the circuit is supposed to be dead. The other hand may preferably be kept in pocket.

g) When it is necessary to touch electrical equipment (for example when checking for overload of motors) back of the hand may be used. Thus, if accidental shock were to cause muscular contractions, one would not 'freeze' to the conductor.

h) Operation of electrical equipment shall be avoided when standing on wet floor or when hands are wet.

i) Before blown fuses are replaced, the circuit shall be locked out and an investigation shall be made for the cause of the short circuit or overload.

j) When two persons are working within reach of each other, they shall never work on different phases of the supply.

k) When structural repairs, modification or painting work are to be undertaken, appropriate measures shall be taken for the protection of persons whose work may bring them into the proximity of live equipment/circuit.

l) It shall be ensured that the insulation and wire size of extension cords are adequate for the voltage and current to be carried.

m) While tapping electricity from the socket, plug top must be used. It shall be ensured that no extension boards are over loaded while tapping. Only standard three pin plugs shall be used for tapping electricity. Broken sockets/plugs shall be replaced immediately with goods ones. Only joint free cables shall be used for connecting equipment/apparatus.

n) Floors shall be kept free from trailing electrical cables to avoid tripping hazard.

o) Power supply to all the machines and lighting fixture, shall be switched off when not in use.

p) Temporary electrical connections shall be removed as soon as the stipulated work is over. After completion of the works, the Contractor shall dismantle the distribution boards and the other facilities he may have erected.

q) Unauthorized tapping of power by others from distribution boards under the control of the contractor shall be prohibited at all circumstances.

r) No flammable materials shall be stored in any working area near the switch boards.

s) Safety work permits shall be used for switching off the main feeder and equipment by the contractor.

t) “MEN ON LINE” “DO NOT SWITCH ON” “DANGER” or “CAUTION” board as applicable shall be used during maintenance works on the electrical equipment.

2.3 Portable electrical equipment

a) Portable electrical equipment shall be regularly examined, tested and maintained to ensure that the equipment and its leads are in good order. Register shall be maintained for inspection recording the testing dates and results of the equipments.

b) All portable appliances shall be provided with three core cable and three pin plug. The third pin of the plug shall invariably be earthed. It shall be ensured that the metal part of the equipment shall be effectively earthed.

c) All connections to portable equipment or machines from the panel/distribution board/extension board shall be taken using 3 core double insulated PVC flexible copper wire in one length. No joints shall be allowed in this flexible wire. In case single length of wire is not sufficient for a particular location then the supply can be tapped by providing another extension board comprising of switch and socket.

d) Flexible cables for portable lamps, tools, and apparatus shall be regularly examined, tested periodically and maintained to ensure safety.

FORM NO. SGCW – 1

FORM FOR COMPLETION CERTIFICATE

(Prescribed under cl. 1.2 of Annexure)

I/We certify that the installation detailed below has been installed by me/us and tested and that to the best of my/our knowledge and belief, it complies with Indian Electricity Rules, 1956 as well as IS:732-1963 code of practice for Electrical Wiring Installations. (System voltage not exceeding 650 Volts (Revised).

Electric installation at …….

Voltage and system of supply ……..

a)	Particulars of work	Number	Total load	Type of system of wiring
		---	---	---
	i) Light Points			
	ii) Fan points			
	iii) Plug points (3 pin)			
	iv) Motors			

b) If the work involves installation of overhead lines and/or underground cable _____

c) Earthing:

Description of earthing electrode, size of earth wire and number of electrodes provided:

d) Test results:

1. Insulation resistance for the whole installation:

   i) Between conductors
   ii) Between each conductor and earth

2. Resistance of earthing electrode or earthing system.
3. Maximum earthing resistance of installation

Signature of Supervisor
Name and address
of Supervisor.

Signature of Contractor
Name and address
of Contractor.

FORM NO. SGCW – 2

'A' APPLICATION FOR SERVICE CONNECTION BY CONTRACTOR

(Prescribed under cl. 1.3 of Annexure)
(to be filled in triplicate)

1. Name & Address of Contractor :

2. Reference to Tender & Work Order :

3. Completion period :

4. Connected load details (please attach details in a separate sheet) :

5. Max. demand anticipated :

6. Nature of service connection required (whether single or three phase) :

7. Place where service required :

   a) Works :

   b) Colony :

8. If supply of electricity is free or chargeable (please enclose extract of conditions from the tender) :

9. Details of meter provided :

   a) If meter required from the Department, whether SD is paid :

   b) Details of SD (Security Deposit) :

   c) Whether meter is tested or not, if tested, attach test report, if not, details of testing fee deposited :

10. Name of Supervisor/Electrician in charge of installation and maintenance :

11. Electrical license No. of person mentioned against col. 10 :

12. Electrical safety appliances available for use :

13. Fire extinguishers available for use :

14. First Aid facility/box available for use, if any. :

(Signature of the Contractor)

Date: Name:

‘B’ CERTIFICATE BY THE CONTRACTOR

Certified that my/our installations have been carried out in accordance with I.E. Rules and that I/We have employed competent persons to handle the installations.

I/we am/are agreeable to the bills, in respect of this service connections being raised on the basis the connected load furnished above, in case the actual consumption falls below the one stipulated by the tender conditions.

(Signature of the Contractor)

Name :

Address:

Date :

……

‘C’ CERTIFICATE BY THE CONTRACT CONTROL ENGINEER

Verified the particulars and forwarded to the Engineer-in-charge.

(Signature of Contract control Engineer)

Name:

Section: Civil/Electrical/Mechanical.

……

‘D’ CERTIFICATE BY THE ENGINEER IN CHARGE

Certified that the particulars furnished by the Contractor are true to the best of my knowledge and belief and that I have satisfied myself as to the safe conditions of electrical installations for which the service connection is applied for.

Signature :

Name:

Date: Designation with section:

‘E’ CERTIFICATE BY THE SAFETY ENGINEER

Certified that I have inspected the electrical installations referred herein and after satisfying myself about the safe conditions of the installation, I hereby recommend that the service connection be given to the Contractor.

Signature of Safety Engineer.

Name:

Date:

……

‘F’ AUTHORIZATION BY THE ELECTRICAL ENGINEER

Service connection may be/may not be given for the reasons noted hereunder.

Signature of Electrical Engineer.

Name:

Date: Designation:

‘G’ “REPORT OF COMPLIANCE”

Service connection is given by me on

a) Meter Nos. 1.

2.

3.

b) Initial readings: 1.

2.

3.

c) Locations: 1.

2.

3.

d) Meter sealings

Signature of Electrical Engineer
(Metering and Billing)

Name:

Date: Designation:

Note:

1st copy to Contract Control Engineer
2nd copy to Safety Engineer
and 3rd copy to Electrical Engineer

After all the formalities are completed and Report of Compliance in (G) are filled up by the Electrical Engineer after power supply is given.

ANNEXURE-1

IMPORTANT RULES OF ATOMIC ENERGY

(FACTORIES) RULES, 1996

APPLICABLE TO

ENGINEERING, PROCUREMENT
&
CONSTRUCTION CONTRACTS

CHAPTER III

HEALTH

8. RECORD OF WHITEWASHING, ETC.- The record of dates on which whitewashing, colourwashing, varnishing, etc. are carried out shall be entered in a register maintained in a manner specified in Form 2.

9. CLEANLINESS OF WALLS, CEILINGS AND COMPOUND AREA.-

(1) Clause (d) of sub-section (1) of section 11 of the Act shall not apply to the class or description of factories or parts of factories specified in the Table to this rule and subject to the condition that they are kept in a clean state by washing, sweeping, brushing, dusting, vacuum cleaning or other effective and adequate means:

Provided the said clause shall continue to apply-

(a) as respects units/factories or parts of units/factories specified in part A of the said Table, to workrooms in which the amount of cubic space allowed for every person employed in the room is less than 14.0 m^3

(b) as respects factories or parts of factories specified in part B of the said Table, to workrooms in which the amount of cubic space allowed for every person employed in the room is less than 70.0 m^3 ;

(c) to engine-houses, fitting shops, lunchrooms, canteens, shelters, creches, cloakrooms, rest-rooms and wash places; and

(d) to such parts of walls, sides and tops of passages and staircases as are less than 6 m. above the floor or stair.

(2) If it appears to the Competent Authority that any part of a factory, to which by virtue of sub-rule (1) any of the provisions of the said clause (d) do not apply or apply as modified by sub-rule (1), is not being kept in a clean state, it may, by written notice, require the occupier to whitewash or colourwash, wash, paint or varnish the same, and in the event of the occupier failing to comply with such requisition within two months from the date of the notice, sub-rule (1) shall cease to apply to such part of a factory, unless the Competent Authority otherwise determines.

(3) The compound surrounding every factory shall be maintained in a sanitary and clean condition free of rubbish, filth or debris.

TABLE

Part A

1. Chemical works.

2. The following parts of units/factories:-

   (a) Rooms used only for storage of articles.

   (b) Rooms in which the walls or ceilings consist of galvanised iron and/or asbestos cement sheets.

   (c) Rooms in which graphite articles are manufactured / processed

   (d) Parts of walls, partitions, ceilings or tops of rooms which are at least 6 m. above the floor.

Part B

1. Electric generating or transforming stations.

2. Engineering works.

3. Foundries other than foundries in which brass casting is carried on.

10. DISPOSAL OF WASTES AND EFFLUENTS.- The arrangements made in every factory after the treatment of wastes and effluents due to the manufacturing processes carried on therein shall be in accordance with those approved by the relevant Water and Air pollution Boards appointed under Water (Prevention & Control of Pollution) Act, 1974, the Air (Prevention & Control of Pollution) Act, 1981, the Environmental Protection Act, 1986 and such other authorities as may be notified by the Central Government in this behalf.

11. ILLUMINATION, TEMPERATURE AND VENTILATION.-

(1) Illumination.-

   (a) General : Adequate lighting is necessary for all buildings and in the open area so as to-

      (i) promote work and other activities carried out in the area;

      (ii) promote safety of the people; and

      (iii) create a pleasing environment conducive for feeling of well-being.

   (b) Adequate lighting will be achieved by,-

(i) planning of brightness in relation to task itself, immediate background of the task and the general surrounding;

(ii) avoiding glare produced by excessive contrast or abrupt and large change in brightness; and

(iii) planning of lighting for movement about a building and around.

(c) The recommended values of illumination for different locations is given in the Table below:

TABLE

Sr.No.	Visual Tasks			Illumination (Lux)
1.	Industrial Buildings & Process			
	(a)	General Factory Areas		100-150
		-canteens, cloakrooms, entrances		
		corridors, stairs		
	(b)	Factory- outside Areas		
		-Stockyards, main entrances		20
	(c)	Assembly, Inspection, Wood working,		
		Welding & Soldering, Machine & Fitting		
		Shops,		
		(i)	Rough Work - Frame assembly	150
		(ii)	Medium Work - Assembly of parts	300
		(iii)	Fine Work - Electronic assembly,	700
			inspection	
		(iv)	Very Fine Work - Assembly of	1500
			precision parts, optical aids	
			to be provided.	
		(v)	Very Precise Work	3000
	(d)	Boiler Houses		
		(i)	Coal & ash handling	100
		(ii)	Boiler rooms-operating area	100
		(iii)	Boiler rooms- other areas	20-50
		(iv)	Outdoor plants	150

Rule 11(Tab.)

(e)	Chemical Works		
	(i) Hand furnace, boiling tanks, driers, evaporators etc.		150
	(ii) Controls, gauges, valves etc. (Supplementary lighting for viewing)		100
	(iii) Control rooms		200-300
(f)	Electricity Generating Station (indoor)		
	(i) Turbine halls		200
	(ii) Auxiliary equipment areas	100	
	(iii) Boiler houses		70-100
	(iv) Boiler house & Turbine house		100
	(v) Basement areas		70
	(vi) Conveyer areas		70-100
	(vii) Control rooms		200-300
	(viii) Nuclear reactors & steam generating plants		150-200
	(g) Engraving		1000
	(h) Foundries		
	(i) Charging floors, tumbling etc.		150
	(ii) Fine moulding, core making & inspection		300
	(iii) Repairs		300
	(i) Garages		
	(i) Parking areas		70
	(ii) Washing, polishing etc.		150
	(iii) Repairs		300
	(j) Gauge & Tool room (Supplementary lighting if required)		700

Rule 11(Tab.)

(k)	Laboratories & Test Rooms		
	(i)	General Labs & balance rooms	300
	(ii)	Electronic & Instrument Labs	450
(l)	Laundries, Dry cleaning & ironing		200-300
(m)	Paint Shops & Spraying Booths		
	(i)	Dipping, rubbing	150-300
	(ii)	Fine painting & retouching	450-700
(n)	Plating Shops		
	(i)	Vat & baths	150
	(ii)	Final buffing & polishing	Special lighting
(o)	Structural Steel Fabrication Plants		
	(i)	General	150
	(ii)	Marking off	300
(p)	Libraries		
	(i)	Shelves	70-150
	(ii)	Reading rooms	150-700
	(iii)	Cataloguing, sorting	150-300
	(iv)	Book binding etc.	300-700
(q)	Offices		
	(i)	Entrance & Reception	150
	(ii)	Conference rooms & Gen. office	30
	(iii)	Drawing offices	300-450
	(iv)	Corridors & Lifts	70
	(v)	Stairs, Lift landing	100-150
	(vi)	Telephone exchanges	150-200

Rule 11(Tab.)

(r)	Hospitals		
	(i)	General & Wards	150
	(ii)	Operating Theatres General	300
	(iii)	Operation table	Special lighting
	(iv)	Laboratories	300
	(v)	Radiological rooms	100
	(vi)	Other areas	100-300
(s)	Restaurants		
	(i)	Dining room tables	100
	(ii)	Self service counters	300
	(iii)	Kitchen	200
	(iv)	Cloak room & toilets	100

(2) Temperature.- It is essential to provide such temperature in work environment so that workers can be exposed to it repeatedly without adverse health effects. The nature of work can be light , moderate or heavy and the corresponding heat loads for the type of work are 200, 200-350 & 350-500 K Cal/hr. The heat stress is measured in terms of Wet Bulb Globe Temperature (WBGT) Index.* (* Note - on page 12)

The permissible WBGT index in degrees Celsius is given in the following WBGT Table.

WBGT TABLE

	Work Load		
Work-Rest Regimen in each hour	Light	Moderate	Heavy
Continuous Work	30.0	26.7	25.0
75% Work - 25% Rest	30.6	28.0	25.9
50% Work - 50% Rest	31.4	29.4	27.9
25% Work - 75% Rest	32.2	31.1	30.0

The Competent Authority shall specify the optimum working temperature & humidity and also the rest periods for specific factories & jobs.

Rule 11(Tab.)

(3) Ventilation.- Ventilation shall be provided in buildings to supply fresh air for respiration & to dilute inside air to prevent vitiation by body odours & to remove any other products of combustion or other air contaminants. Contaminants from concentrated sources such as smoke, heat & fumes shall be collected separately by local exhaust ventilation. The recommended air changes per hour for various areas is given in the Table below:

TABLE

Area	**Air Changes/hour**
Factories	3 - 6
Dining Hall	12 - 15
Garages	12 - 15
Kitchen	6 - 9
Laboratories	3 - 6
Offices	3 - 6
Bathrooms & Toilets	6 - 12

Provided that the competent authority may relax the requirements regarding the number of air changes if it is satisfied that having regard to the location of the factory, orientation of the workroom, prevailing winds, roof height and the nature of manufacturing process carried on, sufficient supply of fresh air into the workroom is afforded during most part of the working time:

Provided further that in the regions where in summer (15th March-15th July) dry-bulb temperatures of outside air in the shade during most part of the day exceed 35 degrees Celsius and simultaneous wet-bulb temperatures are 25 degrees Celsius or below and in the opinion of the Inspector the manufacturing process carried on in the workroom of a factory permits thermal environments with relative humidity of 50% or more, the Inspector may serve on the manager of the factory an order to have sufficient supply of outside air for ventilation cooled by

* (a) Outdoors with Solar load

WBGT = 0.7NWB + 0.2GT + 0.1DB

(b) Indoor or Outdoor without Solar load

WBGT = 0.7 NWB + 0.3GT

Where NWB = Natural Wet Bulb Temperature

DB = Dry Bulb Temperature

GT = Globe Thermometer Temperature

passing it through water sprays either by means of unit type of evaporative air coolers(desert coolers) or, where supply of outside air is provided by mechanical means through ducts in a plenum system, by means of central air washing plants.

12. QUANTITY OF DRINKING WATER.- The quantity of drinking water to be provided per day for the workers in every factory shall be at least 5 litres per worker employed in the factory and such drinking water shall be readily available at all times during working hours.

13. SOURCE OF SUPPLY.- The water provided for drinking shall be supplied,-

(a) from the public water supply system, or

(b) from any other source approved in writing by the local Health Officer concerned.

14. MEANS OF SUPPLY.- If drinking water is not supplied directly from taps either connected with public water supply system or any other water supply system of the factory approved by the local Health Officer concerned, it shall be kept in suitable vessels, receptacles or tanks fitted with taps and having dust proof covers, and placed on raised stands or platforms in shade and having suitable arrangement of drainage to carry away the spilt water. Such vessels, receptacles or tanks shall be kept clean and the water renewed at least once every day. All practicable measures shall be taken to ensure that the water is free from contamination.

15. CLEANLINESS OF WELL OR RESERVOIR.-

(1) Drinking water shall not be supplied from any open well or reservoir unless it is so constructed, situated, protected and maintained as to be free from the possibility of pollution by chemical, or bacterial and extraneous impurities.

(2) Where drinking water is supplied from such a well or reservoir, the water in it shall be sterilised once a week or more frequently if the inspector by written order so requires, and the date on which sterilising is carried out shall be recorded:

Provided that this requirement shall not apply to any such well or reservoir if the water therein is filtered and treated to the satisfaction of the local Health Officer concerned before it is supplied for consumption.

16. REPORT FROM LOCAL HEALTH OFFICER CONCERNED.- The Inspector may by order in writing direct the manager to obtain, at such time or at such intervals as he may direct, a report from the local Health Officer concerned as to the fitness for human

consumption of the water supplied to the workers, and to submit to the Inspector a copy of such report as soon as it is received from the local Health Officer.

17. COOLING OF WATER.- In every factory wherein more than two hundred and fifty workers are ordinarily employed,-

(1) The drinking water supplied to the workers shall be cooled by an effective method for the period specified by the Inspector;

(2) The cool drinking water shall be supplied in every canteen, lunchroom and rest-room and also at conveniently situated points throughout the factory which for the purpose of the rules shall be called "water centres";

(3) The water centres shall be sheltered from the weather and adequately drained and shall be located outside the work-places where toxic materials are handled or processed;

(4) The number of water centres to be provided shall be one "centre" for every 150 persons employed at any one time in the factory:

Provided that in the case of a factory where the number of persons employed exceeds 500 it shall be sufficient if there is one such "centre" as aforesaid for every 150 persons up to the first 500 and one for every 500 persons thereafter:

Provided further that its distance between the place of work shall be such as may be specified by the Inspector.

(5) Every water centre shall be maintained in a clean and orderly condition; and

(6) The means of supply of cooled drinking water shall be either directly through taps connected to water coolers or any other system for cooling of water, or by means of vessels, receptacles or tanks fitted with taps and having dust proof covers and placed on raised stands or platforms in shade, and having suitable arrangement of drainage to carry away the spilt water. Such vessels, receptacles or tanks shall be kept clean and the water refilled at least once every day.

18. LATRINE ACCOMMODATION.- Latrine accommodation shall be provided in every factory on the following scale, namely:-

(a) where females are employed, there shall be at least one latrine for every 25 females;

(b) where males are employed, there shall be at least one latrine for every 25 males;

Provided that where the number of males exceeds 100, it shall be sufficient if there is one latrine for every 25 males up to the first 100 males, and one for every 50 males thereafter.

Note:- In calculating the number of latrines required under this rule, any odd number of workers less than 25, or 50 as the case may be, shall be reckoned as 25 or 50.

19. **TOILET BLOCKS .**- The toilet block shall consist of wash basins, latrines and urinals (in case of male workers). The number of wash basins will the same as number of latrines. Each wash basin shall be provided with mirror and liquid/cake soap. Each toilet block shall be provided with clean towel or electric hand drier. The number, size and location of the toilet block shall be as per the decision of Inspector & Public Health Authority.

20. **PRIVACY OF TOILET.**- Every latrine shall be under cover and so partitioned off as to secure privacy, and shall have a proper door and fastenings, which shall be maintained in good working order at all time.

21. **SIGN BOARDS TO BE DISPLAYED**.- Where workers of both sexes are employed, there shall be displayed outside each latrine block a notice "For Men Only" or "For Women Only" as the case may be, in the language understood by the majority of the workers. The notice shall also bear the figures of a man or of a woman as the case may be.

22. **URINAL ACCOMMODATION.**- Urinal accommodation shall be provided for the use of male workers and there shall be at least one urinal for every 50 males:

Provided that where the number of males employed exceeds 500, it shall be sufficient if there is one urinal for every 50 males up to the first 500 employed, and one for every 100 thereafter.

Note:- In calculating the urinal accommodation required under this rule any odd number of workers less than 50, or 100, as the case may be, shall be reckoned as 50 or 100.

23. **URINALS TO CONFORM TO PUBLIC HEALTH REQUIREMENTS.**- Urinals other than those connected with an efficient water-borne sewage system, and urinals in a factory wherein more than two hundred and fifty workers are ordinarily employed shall comply with the requirements of the Public Health Authorities.

24. **CERTAIN LATRINES AND URINALS TO BE CONNECTED TO SEWERAGE SYSTEM.-** When any general system of underground sewerage with an assured water supply for any particular locality is provided in a municipality, all latrines and urinals of a factory situated in

such locality shall, if the factory is situated within 30 metres of an existing sewer, be connected with that sewerage system suitably.

25. WHITEWASHING, COLOURWASHING OF LATRINES AND URINALS.- The walls, ceilings and partitions of every latrine and urinal shall be whitewashed or colourwashed and the whitewashing or colourwashing shall be repeated at least once in a period of four months. The dates on which the whitewashing or colourwashing is carried out shall be entered in the prescribed register (Form 2):

Provided that this rule shall not apply to latrines and urinals, the walls, ceilings or partitions of which are laid in glazed tiles or otherwise finished to provide a smooth, polished, impervious surface and that they are washed with suitable detergents and disinfectants at least once in every period of four months.

26. CONSTRUCTION AND MAINTENANCE OF DRAINS.- All drains carrying waste or sullage water shall be constructed in masonry or other impermeable material and shall be regularly flushed and the effluent disposed of by connecting such drains with a suitable drainage line:

Provided that where there is no such drainage line, the effluent shall be deodorized and rendered innocuous and then disposed of in a manner suitable to the satisfaction of the local Health Officer concerned.

27. WATER TAPS IN LATRINES.- Where piped water supply is available, a sufficient number of water taps, conveniently accessible, shall be provided in or near latrine accommodation. A tap per each latrine is to be preferred. There shall be at least one tap for every ten latrines or part thereof. The water taps shall be connected to the Municipal water supply or to an overhead storage tank of sufficient capacity, so that water is available from the taps during all hours when the workers are in the factory. Wherever commode type of latrines are provided arrangements shall be made for providing toilet paper and soap solution, in addition to the water tap. The toilet paper and soap solution shall be regularly replenished.

28. NUMBER AND LOCATION OF SPITTOONS.- The number and location of the spittoons to be provided shall be to the satisfaction of the Inspector. Such spittoons shall be placed on a stand or a bracket 90 cm. high.

29. TYPE OF SPITTOONS.- The spittoons shall be of either of the following types, namely:-

(a) a galvanized iron container with a conical funnel-shaped cover. A layer of suitable disinfectant liquid shall always be

maintained in the container; or

(b) a container filled with dry clean sand, and covered with a layer of bleaching powder; or

(c) any other type approved by the Competent Authority.

30. CLEANING OF LATRINES, URINALS, WORKPLACES & SPITTOONS.- Latrines, urinals, washplaces & spittoons shall be maintained in clean & sanitary conditions by employing adequate number of sanitary staff.

31. Qualifications of competent person with reference to various Sections of the Act are given in the schedule below.

SCHEDULE

The Competent Person is a person who is having a degree in the discipline mentioned or equivalent followed by experience as specified, in responsible position in the field and designated by the Competent Authority.

Sl. No.	Rules made under section of the Act requiring competency	Type of work	Discipline	Experience
1	2	3	4	5
1.	Section(6)	Civil construction structural work.	Civil & structural engineering	Minimum 10 yrs in design, construction testing or repairs of structures, knowledge of various codes pertaining to the non destructive testing methods.
2.	Section21(2)	Operation of dangerous machines	Electrical or mechanical engineering or equivalent	Minimum 7 yrs in design, operation maintenance, testing of relevant machinery, guards, safety devices etc.
3.	Section 28	Lifts & Hoists	- do -	Min. 7 yrs. in design, erection maintenance, inspection and test procedures of Hoists & lifts.

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1	2	3	4	5
4.	Section 29	Lifting Machinery Lifting tackles	Electrical, Mechanical or Metallurgical	Min.7 yrs. in design, erection maintenance, inspection. testing of lifting machinery or lifting tackle
5.	Section 31	Pressure plant	Chemical, Electrical or mechanical or metallurgical Engineering or equivalent	Min. 10 yrs experience in design, erection, maintenance, testing examination, inspection of pressure plants and knowledge of non destructive testing & codes of safety requirement of pressure vessels.
6.	Section 36	Dangerous fumes	Chemical engineering or masters degree in chemistry	Min.7 yrs. experience in collection and analysis of environmental samples and calibration of monitoring equipment.
7.	Section 41-C (b)	Supervision of handling of hazardous substances	Chemical engineering or masters degree in chemistry	Min. 7 yrs. experience on the shop floor in handling & disposal of hazardous chemicals.
8.	Section 87	Ventilation system	Electrical or mechanical engg.	Min.7 yrs. in design, fabrication, installation, testing of ventilation systems and systems used for collection of dusts, fumes etc.

Rule 32(Sch.)

CHAPTER IV

SAFETY

32. Without prejudice to the provisions of sub-section (1) of section 21 of the Act in regard to fencing , the further precautions specified in Schedules annexed here to shall apply to machines mentioned in each Schedule.

SCHEDULE I

WOODWORKING MACHINERY

1. Definitions.-For the purposes of this schedule -

(a) "woodworking machine" means a circular saw, band saw, planing machine, chain mortising machine or vertical spindle moulding machine operating on wood or cork;

(b) "circular saw" means a circular saw working in a bench (including a rack bench), but does not include a pendulum or similar saw which is moved towards the wood for the purpose of cutting operation;

(c) "band saw" means a band saw, the cutting portion of which runs in a vertical direction but does not include a log saw or band re-sawing machine; and

(d) "planing machine" means a machine for overhead planing or for thicknessing or for both operations.

2. Stopping and starting device.- An efficient stopping and starting device shall be provided on every woodworking machine. The control of this device shall be in such a position as to be readily and conveniently operated by the person in charge of the machine.

3. Space around machines.- The space surrounding every woodworking machine in motion shall be kept free from obstruction.

4. Floors.-The floor surrounding every woodworking machine shall be maintained in good and smooth condition, and shall not be allowed to become slippery, and as far as practicable shall be kept free from chips or other loosely scattered material.

5. Training and supervision.-

(a) No person shall be employed at a woodworking machine unless he has been sufficiently trained to work that class of machine, or unless he works under the adequate supervision of a person who has a thorough knowledge of the working of the machine.

(b) A person who is being trained to work a woodworking machine shall be fully and carefully instructed as to the dangers of the machine and the precautions to be observed to secure safe working of the machine.

6. Circular saws.-Every circular saw shall be fenced as follows:-

(a) behind and in direct line with the saw there shall be a riving knife, which shall have a smooth surface, shall be strong, rigid and easily adjustable, and shall also conform to the following conditions:-

(i) the edge of the knife nearer the saw shall form an arc of a circle having a radius not exceeding the radius of the largest saw used on the bench;

(ii) the knife shall be maintained as close as practicable to the saw, having regard to the nature of the work being done at the time, and at the level of the bench table. The distance between the front edge of the knife and the teeth of the saw shall not exceed 12 millimeters; and

(iii) for a saw of a diameter of less than 60 cm., the knife shall extend upwards from the bench table to within 25 mm. of the top of the saw, and for a saw of a diameter 60 cm. or over shall extend upwards from the bench table to a height of at least 23 cm.

(b) the top of the saw shall be covered by a strong and easily adjustable guard, with a flange at the side of the saw farthest from the fence. The guard shall be kept so adjusted that the said flange shall extend below the roots of the teeth of the saw. The guard shall extend from the top of the riving knife to a point as low as practicable at the cutting edge of the saw; and

(c) the part of the saw below the bench table shall be protected by two plates of metal or other suitable material, one on each side of the saw; such plates shall not be more than 15 cm. apart, and shall extend from the axis of the saw outwards to a distance of not less than 5 cm. beyond the teeth of the saw. Metal plates, if not beaded, shall be of a thickness of at least 2.5 mm., or if beaded, be of a thickness of at least 1.25 mm.

7. Push Sticks.-A push stick or other suitable appliance shall be provided for use at every circular saw and at every vertical spindle moulding machine to enable the work to be done without unnecessary risk.

8. Band saws.-Every band saw shall be guarded as follows:-

(a) both sides of the bottom pulley shall be completely encased by sheet or expanded metal or other suitable material;

(b) the front of the top pulley shall be covered with sheet or expanded metal or other suitable material; and

(c) all portions of the blade shall be enclosed or otherwise securely guarded, except the portion of the blade between the bench table and the top guide.

9. Planing machines.-

(a) A planing machine (other than a planing machine which is mechanically fed) shall not be used for overhand planing unless it is fitted with a cylindrical cutter block.

(b) Every planing machine used for overhand planing shall be provided with a "bridge" guard capable of covering the full length and breadth of the cutting slot in the bench, and so constructed as to be easily adjusted both in a vertical and horizontal direction.

(c) The feed roller of every planing machine used for thicknessing, except the combined machine for overhand planing and thicknessing, shall be provided with an efficient guard.

10. Adjustment and maintenance of guards.-The guards and other appliances required under this schedule shall be -

(a) maintained in an efficient state;

(b) constantly kept in position while the machinery is in motion; and

(c) so adjusted as to enable the work to be done without unnecessary risk.

11. Exemptions.-Paragraphs 6, 8, 9 and 10 shall not apply to any woodworking machine in respect of which it can be proved that other safeguards are provided, maintained and used which render the machine as safe as it would be if guarded in the manner prescribed in this schedule.

SCHEDULE II

CENTRIFUGAL MACHINES

1. Definition.-"Centrifugal machines" include centrifugal extractors, separators and driers.

2. Every part of centrifugal machine shall be

(a) of good design and construction and of adequate strength;

(b) properly maintained; and

(c) examined thoroughly by a competent person at regular intervals to check for unbalance & in case unbalance at high speeds is observed steps to restore the balance shall be taken before commissioning the machine.

3. Interlocking guard for drum or basket.-

(a) The cage housing the rotating drum or basket of every centrifugal machine shall be provided with a strong lid. The design and construction of the cage as well as the lid shall be such that no access is possible to the drum or basket when the lid is closed.

(b) Every centrifugal machine shall be provided with an efficient interlocking device that will effectively prevent the lid referred to in sub-paragraph (a) from being opened while the drum or basket is in motion and prevent the drum or basket being set in motion while the lid is in the open position.

4. Braking arrangement.-Every centrifugal machine shall be provided with an effective braking arrangement capable of bringing the drum or basket to rest within as short a period of time as reasonably practicable after the power is cut off.

5. Operating speed.-No centrifugal machine shall be operated at a speed in excess of the manufacturer's rating which shall be legibly stamped at easily visible places both on the inside of the basket and on the outside of the machine casing.

SCHEDULE III

POWER PRESS

1. Application.- The Schedule shall apply to all types of power presses including press brakes, except when used for working hot metal.

2. Definition.- For the purpose of this Schedule -

(a) "approved" means approved by the Competent Authority;

(b) "fixed fencing" means fencing provided for the tools of a power press being fencing which has no moving parts associated with or dependent upon the mechanism of a power press and includes that part of a closed tool which acts as a guard;

(c) "power press" means a machine used in metal or other industries for moulding, pressing, blanking raising drawing and similar purposes;

(d) "safety device" means the fencing and any other safeguard provided for the tools of a power press.

3. Starting and stopping mechanism.- The starting and stopping mechanism shall be provided with a safety stop so as to prevent

over running of the press or descent of the ram during tool setting, etc.

4. Protection of tool and die.-

(a) Each press shall be provided with a fixed guard with a slip plate on the underside enclosing the front and sides of the tool.

(b) Each die shall be provided with a fixed guard surrounding its front and sides, and extending to the back in the form of a tunnel through which the pressed article falls to the rear of the press.

(c) The design, construction and mutual position of the guards referred to in (a) and (b) such as to preclude the possibility of the worker's hand or fingers approaching the danger zone.

(d) The machine shall be fed through a small aperture at the bottom of the die guard, but a wider aperture may be permitted for second or subsequent operations if feeding is done through a chute.

(e) Notwithstanding anything contained in sub-clauses (a) and (b) an automatic or an inter-locked guard may be used in place of a fixed guard, but where such guards are used they shall be maintained in an efficient working condition and if any guard develops a defect, the power press shall not be operated unless the defect of the guard is removed.

5. Appointment of persons to prepare power presses for use .-

(a) Except as provided in paragraph (4), no person shall set, re-set, adjust or try out the tools on a power press or install or adjust any safety device thereon, being installation or adjustment preparatory to production of die proving, or carry out an inspection and test of any safety device thereon required by paragraph 8 unless he-

(i) has attained the age of eighteen;

(ii) has been trained in accordance with the sub-paragraph (b); and

(iii) has been appointed by the occupier of the factory to carry out those duties in respect of the class or description of power press or the class or description of safety device to which the power press or the safety device (as the case may be) belongs; and the name of every such person shall be entered in a register in Form 1.

(b) The training shall include suitable and sufficient practical instruction in the matters in relation to each type of power press & safety device in respect of which it is proposed to appoint the person being trained.

6. Examination and testing of power presses and safety devices.-

(a) No power press or safety device shall be taken into use in any factory for the first time in that factory, or in case of a safety device for the first time on any power press, unless it has been thoroughly examined and tested, in the case of a power press, after installation in the factory, or in the case of a safety device, when in position on the power press in connection with which it is to be used.

(b) No power press shall be used unless it has been thoroughly examined and tested by a competent person within the immediately preceding period of 12 months.

(c) No power press shall be used unless every safety device (other than fixed fencing) thereon has within the immediately preceding period of six months when in position on that power press, been thoroughly examined and tested by a competent person.

(d) The competent person carrying out an examination and test under the foregoing provisions shall make a report of the examination and test containing the following particulars and every such report shall be kept readily available for inspection:

(i) name of the occupier of the factory;

(ii) address of the factory;

(iii) identification number or mark sufficient to identify the power press or the safety device;

(iv) date on which the power press or the safety device was first taken into use in the factory;

(v) the date of each periodical thorough examination carried out as per requirements of sub-paragraph (b) above;

(vi) particulars of any defects affecting the safe working of the power press or the safety device found at any such thorough examination and steps taken to remedy such defects;

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7. Defects disclosed during a thorough examination and tests .-

(a) Where any defect is disclosed in any power press or in any safety device by any examination and test under paragraph 6 and in the opinion of the competent person carrying out the examination and test, either-

(i) the said defect is a cause of danger to workers and in consequence the power press or safety device (as the case may be) ought not to be used until the said defect has been remedied; or

(ii) the said defect may become a cause of danger to workers and in consequence the power press or safety device (as the case may be) ought not to be used after the expiration of a specified period unless the said defect has been remedied.

Such defect shall, as soon as possible after the completion of the examination and test, be notified in writing by the competent person to the occupier of the factory and, in the case of a defect falling within clause (ii) of this sub-paragraph such notification shall include the period within which, in the opinion of the competent person, the defect ought to be remedied.

(b) In every case where notification has been given under this paragraph, a copy of the report made under paragraph 6(d) shall be sent by the competent person to the inspector for the area within fourteen days of the completion of the examination and test.

(c) Where any such defect is notified to the occupier in accordance with the foregoing provisions of this paragraph the power press or safety devise (as the case may be) having the said defect shall not be used -

(i) in the case of a defect falling within clause(i) of sub- paragraph (a) until the said defect has been remedied; and

(ii) in the case of defect falling within clause (ii) of sub-paragraph (a), after the expiration of the specified period.

(d) As soon as is practicable after any defect of which notification has been given under sub-paragraph(a) has been remedied, a record shall be made by or on behalf of the occupier stating the measures by which and the date on which the defect was remedied.

8. Inspection and test of safety devices.-

(a) No power press shall be used after the setting, resetting or adjustment of the

tools thereon unless a person appointed or authorised for the purpose under Paragraph 5 has inspected and tested every safety device thereon while it is in position on the said power press:

Provided that any inspection, test and certificate as aforesaid not be required where any adjustment of the tools has not caused or resulted in any alteration to or disturbance of any safety device on the power press and if, after the adjustment of the tools, the safety devices remain, in the opinion of such a person as aforesaid, in efficient working order.

(b) Every power press and every safety device thereon while it is in position on the said power press shall be inspected and tested by a trained person every day.

9. Defects disclosed during an inspection and test.-

(a) Where it appears to any person as a result of any inspection and test carried out by him under paragraph 8 that any necessary safety device is not in position or is not properly in position on a power press or that any safety device which is in position on a power press is not in his opinion suitable, he shall notify the manager forthwith.

(b) Except as provided in sub-paragraph (c) where any defect is disclosed in a safety device by any inspection and test under paragraph 8, the person carrying out the inspection and test shall notify the manager forthwith.

(c) Where any defect in a safety device is the subject of a notification in writing under paragraph 7 by virtue of which the use of the safety device may be continued during a specified period without the said defect having been remedied, the requirement in sub-paragraph (b) of this paragraph shall not apply to the said defect until the said period has expired.

10. Identification of power presses and safety devices.- For the purpose of identification every power press and every safety device provided for the same shall be distinctively and plainly marked.

11. Training and instructions to operators.- The operators shall be trained and instructed in the safe method of work before starting work on any power press. It shall be ensured by adequate supervision that correct operating procedures are being followed.

12. Exemptions.-

(a) If in respect of any factory, the Competent Authority is satisfied that owing to the circumstances or infrequency of the processes or for any other reason, all or any of the provisions of this Schedule are not necessary for the

protection of the workers employed on any power press or any class or description of power press or in the factory, the Competent Authority by a certificate in writing(which he may in his discretion revoke at any time), exempt such factory from all or any of such provisions subject to such conditions, if any, as he may specify therein.

(b) Where such exemption is granted, a legible copy of the certificate, showing the conditions (if any) subject to which it has been granted, shall be kept posted in the factory in a position where it may be conveniently read by the persons employed.

SCHEDULE IV

WELDING AND GAS CUTTING

1. Arc Welding.-

(a) Definition.- Arc welding is a welding process wherein coalescence is produced by heating with an electric arc, with or without application of pressure and with or without the use of filler metal.

(b) Correct and proper electric earthing shall be provided for the welding machine, the casing and the job to be welded. These shall be electrically checked for any leakage of current by an authorised and trained electrician.

(c) The welding machine shall be kept at a dry place and materials shall not be kept around it.

(d) The welding cable shall be in good condition. The metal wire shall not be in an exposed state anywhere. The welding cable connections shall be tight. The cable shall not lie on wet surface nor shall it pass through water. Building structure, fuel tanks, railings etc., shall not be used to support welding cables. As far as possible cable shall not be laid across the passages.

(e) The welder shall not wear any wet dresses, footwear, hand gloves etc. These articles must be dry before working with welding machines. The welder shall wear rubber shoes, hand gloves and use welding screens while doing welding jobs. Welding screen shall be used around the welding area to stop welding flashes from affecting others. The welder must check the welding holder thoroughly before starting the job and shall also see that the insulation of the holder is proper.

(f) The welding cable and holder etc., shall be fastened to the overhead structures with non-conductors to prevent these from dropping down.

(g) Scaffolding made of corrugated sheets shall be used below the areas where welding is to be done to prevent sparks dropping down below.

(h) While welding in confined areas like inside of tanks, pipes etc., proper ventilation shall be provided with the help of a fan.

(i) Welding on a gas or fuel line shall never be done without a special approved procedure written specially for the particular job.

(j) All welding work shall be started only after obtaining a welding permit from authorised agency indicating special precautions including the fire fighting details.

(k) For welding work on overhead equipment such as crane etc. a separate earth cable shall be run up to the work place and shall be connected to work piece.

2. Gas Cutting.-

(a) Definition.- Gas cutting is a process used for cutting mild steel by a flame torch using compressed gases Hydrogen/Acetylene and oxygen to preheat the metal and cutting it by forcing oxygen at higher pressure.

(b) The gas cylinders shall be kept well away from any fire or hot areas. The rubber pipes, joints, gas torches, valve connections shall be thoroughly checked for leakage of gas.

(c) The gas cutter shall use proper safety appliances viz. gas cutters goggles, hand gloves, safety shoes, helmets and safety belts.

(d) The rubber hose shall not come in contact with any hot material and it shall not be taken through hot areas.

(e) The gas torch shall be fastened to a fixed overhead structural or with the body of the gas cutter to stop it from dropping down.

(f) The rubber hose shall not obstruct the movement of others. When necessary to lower the rubber hose with fittings, a fibre rope should be used. A metal sheet shall be used below the job to arrest any sparks/hot slags from falling down.

(g) Before starting any gas cutting, a written permit clearance shall be obtained from authorised person which will indicate all Safety precautions including fire fighting details.

(h) Gas cutting at or near fuel line/hazardous area etc., shall be done only after obtaining a special approved procedure for that job.

(i) Provisions of Gas Cylinder Rules shall be complied with.

Rule 32 (Sch.V)

SCHEDULE V

SHEARS, SLITTERS AND GUILLOTINE MACHINES

1. Definition.- For the purpose of this Schedule -

   (a) "guillotine" means a machine ordinarily equipped with straight, bevel-edged blade operating vertically against a stationery resisting edge and used for cutting metallic or non- metallic substances;

   (b) "shears" or "shearing machine" means a machine ordinarily equipped with straight, bevel-edged blades operating vertically against resisting edges, or with rotary, overlapping cutting wheels, and used for shearing metals or non-metallic substances; and

   (c) "slitter" or "slitting machine" means a machine ordinarily equipped with circular disc-type knives, and used for trimming or cutting into metal or non-metallic substances or for slitting them into narrow strips; for the purpose of this Schedule, this term includes bread or other food slicers equipped with rotary knives or cutting discs.

2. Guillotine and Shears.-

   (a) Where practicable, a barrier metal guard of adequate strength shall be provided at the front of the knife, fastened to the machine frame and shall be so fixed as would prevent any part of the operator's body to reach the descending blade from above, below or through the barrier guard or from the sides:

   Provided that in case of machines used in the paper printing and allied industries, where a fixed barrier metal guard is not suitable on account of the height and volume of the material being fed, there shall be provided suitable starting devices which require simultaneous action of both the hands of the operator or an automatic device which will remove both the hands of the operator from the danger zone at every descent of the blade.

   (b) At the back end of such machines, as inclined guard shall be provided over which the slit pieces would slide and be collected at a safe distance in a manner as would prevent a person at the back from reaching the descending blade.

   (c) Power-driven guillotine cutters, except continuous feed trimmers, shall be equipped with -

      (i) starting devices which require the simultaneous action of both hands to start the cutting motion and of at least one hand on a control during the complete stroke of the knife; or

(ii) an automatic guard which will remove the hands of the operator from the danger zone at every descent of the blade, used in conjunction with one-hand starting devices which require two distinct movements of the device to start the cutting motion, and so designed as to return positively to the non-starting position after each complete cycle of the knife.

(d) Where two or more workers are employed at the same time on the same power-driven guillotine cutter equipped with two- hand control the device shall be so arranged that each worker shall be required to use both hands simultaneously on the safety trip to start the cutting motion, and at least one hand on a control to complete the cut.

(e) Power-driven guillotine cutters, other than continuous trimmer, shall be provided, in addition to the brake or other stopping mechanism, with an emergency device which will prevent the machine from operating in the event of failure of the brake when the starting mechanism is in the non-starting position.

3. Slitting Machines.-

(a) Circular disc-type knives on machines for cutting metal and leather, paper, rubber, textiles or other non-metallic substances shall, if within reach of operators standing on the floor or working level, be provided with guards enclosing the knife edges at all times as near as practicable to the surface of the material, and which may either-

(i) automatically adjust themselves to the thickness of the material; or

(ii) be fixed or manually adjusted so that the space between the bottom of the guard and the material will not exceed 6 mm (1/4 in.) at any time.

(b) Portions of blades underneath the tables or benches of slitting machines shall be covered by guards.

4. Index Cutters and Vertical Paper Slotters.- Index cutters, and other machines for cutting strips from the ends of books, and for similar operations, shall be provided with fixed guards, so arranged that the fingers of the operators cannot come between the blades and the tables.

5. Corner Cutters.- Corner cutters, used in the manufacture of paper boxes, shall be equipped with -

(a) suitable guard fastened to the machines in front of the knives and provided with slots or perforations to afford visibility of the operations; or

(b) other guards equally efficient for the protection of the fingers of the workers.

Rule 32(Sch.V-VI)

6. Band Knives.- Band wheels on band knives, and all portions of the blades except the working side between the sliding guide and the table on vertical machines, or between the wheel guards on horizontal machines, shall be completely enclosed with hinged guards of sheet metal not less than 1 mm(0.04 in) in thickness or of other material of equal strength.

SCHEDULE VI

AGITATORS AND MIXING MACHINES

1. Definition.- "Agitators and Mixing Machines" means a tank or other container equipped with power-driven mixing arms, blades or paddle wheels fixed to revolvable shafts or other simple mechanical devices for blending stirring liquids with other liquids or with solid substances or combinations of these.

2. When the top of an open agitator tank, beater tank or paddle tank or similar vessel is less than 1 M above the adjacent floor or working level, adequate standard railings shall be installed on all open sides.

3. Agitators and mixing machines shall be provided with an efficient inter-lock arrangement for the top lid, to prevent access to the agitating, stirring or similar devices, whilst in motion and would prevent restart under power with the lids in open position.

4. When other inspection or examination openings are provided at the top or sides of the containers vessels of the agitator and mixing machines, such openings shall be provided with standard grill guards as would prevent access of any part of the operator's body coming in contact with agitator stirring or similar devices whilst in motion.

5. When discharge holes, openings, chutes or similar arrangements are provided at bottom or at the sides of the container vessels of the agitator and mixing machines, they shall, be so designed, shaped guarded, or situated as would prevent access of any part of operator's body coming in contact with agitating, stirring or similar devices, whilst in motion inside the vessel.

Rule 32 (Sch. -VII)

SCHEDULE VII

CONVEYORS

1. Application.- The schedule shall apply to all types of conveyors.

2. Definition.- Conveyor means a horizontal, inclined or vertical device for moving or transporting bulk materials, packages & objects in a path predetermined by the design of device and having points of loading or discharge fixed or selective.

3. General.- The conveyors shall be so designed installed, operated & maintained as per the national code & standards. Safe procedures shall be laid down to include the following, namely:-

   (a) All moving parts of conveyors such as gears, sprockets, sheaves etc. shall be guarded;

   (b) The starting switch of conveyor shall be located at such a place so that the operator shall have clear view of the entire conveyor length;

   (c) The entire system shall be so interlocked by electrical or mechanical means that it can stop automatically if there is a blockage at any place along the length;

   (d) Conveyors operating in series shall have controls so designed that if one of the conveyor stops others shall automatically stop;

   (e) Electrical machines operating the conveyors equipped with brakes which are mechanically applied or released by movement of operating device, shall be so designed that if the electrical power is interrupted with brakes in OFF position, load can descend only at controlled speed;

   (f) Antirunaway or backstop devices shall be provided on reversible type of conveyors where reversing can cause hazard;

   (g) Overload protecting devices shall be provided on conveyors which shall disconnect the electrical power. All restarting devices shall remain locked till the cause of overload is removed;

   (h) For conveyors feeding the hopper at or near level of floor, the hopper shall be provided with screen or railing and toe-board;

   (i) Conveyors handling flammable material or fine powders shall have only explosion proof electrical fixtures. The dust levels in the area shall be restricted to PLE Limits by suitable means; and

   (j) Conveyors running in tunnels & pits shall have sufficient clearance at sides for workers engaged in lubricating or repair works.

4. Conveyors at height.-

   (a) Conveyors at elevated locations shall be provided with access platform with toe-board & guard rails.

(b) Conveyors installed within 2 metres of floor or walkway surface shall be provided with crossovers or passages

(c) Overhead conveyors shall be provided with sideboards along the edges & screen guards underneath. Underpasses shall be provided with sheet metal ceiling for protection of the persons crossing.

(d) Conveyors passing through building floors, walls shall have interlocks installed in such a way that all will have to operate at one time to start the system. These switches shall be clearly marked & area near them shall be kept clean and free of obstructions. The openings shall be guarded with hand rails, toe-boards etc.

5. Maintenance.- The operation, maintenance of conveyors shall be done under work permit system keeping in mind the nature of materials handled. The entire mechanism of conveyors, electrical switches, interlocks etc. shall be inspected and maintained regularly especially for brakes, back stops, anti-runaway devices, overload releases and such other safety devices.

6. Fire Fighting.- The entire length of the conveyor shall be covered by installation of fire detection and warning system. Wherever conveyor passes through wall or floor openings, automatic system shall be installed for closing of them to stop the passage of flame through them. Wherever necessary automatic water sprinkler system shall also be provided.

33. Register of workers employed for work on or near machinery in motion.-In every factory a register shall be maintained in Form 1 in which the name and other particulars of every such worker as may be employed for such examination or operation as referred to in the proviso to sub-section (1) of section 21 shall be entered.

34. HOISTS AND LIFTS.-

(1) A register shall be maintained to record particulars of examination of hoists and lifts and shall give particulars as shown in Form 3.

(2) In pursuance of the provisions of sub-section (4) of Section 28, in respect of any class or description of hoist or lift specified in the first column of the following Schedule, the requirements of section 28 specified in the second column of the said Schedule and set opposite to that class or description of hoist or lift shall not apply.

SCHEDULE

Class or description of hoist or lift	Requirements which shall not apply
Hoists or lifts mainly used for raising materials for charging blast furnaces or lime kilns.	Sub-section 1(b) in so far as it requires a gate at the bottom landing; sub-section1(d); sub-section 1(e)
Hoists not connected with mechanical power and which are not used for carrying persons.	Sub-section 1(b) in so far as it requires the hoistway or liftway enclosure to be so constructed as to prevent any person or thing from being trapped between any part of the hoist or lift and any fixed structure or moving part; sub-section 1(e)

35. LIFTING MACHINES, CHAINS, ROPES AND LIFTING TACKLES.-

(1) No lifting machine and no chain, rope or lifting tackle, except a fibre rope or fibre rope sling, shall be taken into use in any factory for the first time in that factory unless it has been tested and all parts have been thoroughly examined by a competent person and a certificate of such a test and examination specifying the safe working load or loads and signed by the person making the test and the examination, has been obtained and is kept available for inspection.

(2) Every jib-crane so constructed that the safe working load may be varied by the raising or lowering of the jib, shall have attached there to either an automatic indicator of safe working loads or an automatic jib angle indicator and a table indicating the safe working load at corresponding inclinations of the jib or corresponding radii of the load. An audio-visual alarm be preferably provided in addition, to give alarm wherever the limits given in table are exceeded.

(3) A table showing the safe working loads of every kind and size of chain, rope or use, and, in the lifting tackle in case of a multiple sling, the safe working loads at different angles of the legs, shall be pasted in the store in which the chains, ropes or lifting tackles are kept, and in prominent positions on the premises, and no chain, rope or lifting tackle not shown in the table shall be used:

Provided that this sub-rule shall not apply in respect of such lifting tackle if the safe working load thereof, or in the case of a multiple sling, the safe working load at different angles of the legs, is plainly marked upon it.

(4) The register to be maintained under clause (a)(iii) of sub-section (1) of Section 29 of the Act shall contain the report as given in Form - 4, giving following particulars and shall be kept readily available for inspection:-

(a) Name of occupier of factory.

(b) Address of factory.

(c) Distinguishing number or mark, if any, and description sufficient to identify the lifting machine, chain, rope, or the lifting tackle.

(d) Date when the lifting machine, chain, rope or lifting tackle was first taken into use in the factory.

(e) Date and number of the certificate relating to any test and examination made under sub-rules (1) and (15) together with the name and address of the person who issued the certificate.

(f) Date of each periodical thorough examination made under clause (a) (iii) of sub-section(1) of Section 29 of the Act and sub-section (3) and by whom it was carried out.

(g) Date of annealing or other heat treatment of the chain and other lifting tackle made under sub-rule (7) and by whom it was carried out.

(h) Particulars of any defects affecting the safe working load found at any such thorough examination or after annealing and of the steps taken to remedy such defects.

(5) All rails on which a travelling crane moves and every track on which the carriage of a transporter or runway moves shall be of proper size and adequate strength and have an even running surface; and every such rail or track shall be properly laid, adequately supported and properly maintained.

(6) To provide access to rail tracks of overhead travelling cranes suitable passage-ways of at least 50 centimeters width with toeboards and double hand rails 90 centimeters high shall be provided alongside, and clear of, the rail tracks of overhead travelling cranes, such that no moving part of the crane can strike persons on the ways, and the passage-way shall be at a lower level than the crane track itself. Safe access ladders shall be provided at suitable intervals to afford access to these passage-ways, and from passage-ways to the rail tracks:

Provided that the Competent Authority may, for reasons to be specified in writing, exempt any factory in respect of any overhead travelling crane from the operation of any provision of this sub-rule subject to such conditions as it may specify.

(7) All chains and lifting tackles except a rope sling shall, unless they have been subjected to such other heat treatment as may be approved by the Competent Authority of Factories, be effectively annealed under the supervision of a competent person at the following intervals:-

(a) all chains, slings, rings, hooks, shackles and swivels used in connection with molten metal or molten slag or when they are made of 12.5 millimeters bar or smaller, once at least in every six months; and

(b) all other chains, rings, hooks, shackles and swivels in general use, once at least in every twelve months:

Provided that chains and lifting tackle not in frequent use shall, subject to the Competent Authority's approval, be annealed only when necessary. Particulars of such annealing shall be entered in a register prescribed under sub-rule (4).

(c) Slinging-

(i) Chains shall not be joined by bolting or wiring links together. They shall not be shortened by tying knots. A chain in which the links are locked, stretched or do not move freely shall not be used. The chain shall be free of kinks and twists. Proper eye splices shall be used to attach the chain hooks.

(ii) Pulley blocks of the proper size shall be used to allow the rope free play in the sheave grooves and to protect the wire rope from sharp bends under load. Idle sling shall not be carried on the crane hook along with a loaded sling. When idle slings are carried they shall be hooked.

(iii) While using multileged slings, each sling or leg shall be loaded evenly and the slings shall be of sufficient length to avoid a wide angle between the legs.

(iv) Sling hitches on loads shall be made under the supervision of experienced persons.

(8) Nothing in the foregoing sub-rule (7) shall apply to the following classes of chains and lifting tackles, namely:-

(a) chains made of malleable cast iron;

(b) plate link chains;

(c) chains, rings, hooks, shackles and swivels made of steel or of any non-ferrous metal;

(d) pitched chains, working on sprocket or pocketed wheels;

(e) rings, hooks, shackles and swivels permanently attached to pitched chains, pulley blocks or weighing machines;

(f) hooks and swivels having screw threaded parts or ball bearing or other case hardened parts;

(g) socket shackles secured to wire ropes by white-metal capping; and

(h) bordeaux connections:

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Provided that such chains and lifting tackles shall be thoroughly examined by a competent person once at least in every twelve months, and particulars entered in the register kept in accordance with sub-rule (4).

(9) Cranes shall be operated only by authorised persons who are well trained and experienced, operators shall ensure that all safety devices are functioning properly before crane is put into operation.

(10) A mobile crane shall be operated so that none of its parts can approach live electric lines closer than 3 m. While lifting loads such a crane shall be located on level ground.

(11) Standard signals shall be used and operators shall recognise signals from only one person during crane operation. Signal men shall direct equipment movement at fills, quarries, pits, intersections or any other place where necessary to prevent possible accidents.

(12) No person shall be permitted to work or walk under a load.

(13) Thorough inspection and load testing of a crane shall be done by a competent person at least once every 12 months. The load to be used for the purpose of testing shall be as follows:

Safe working load Test load

Up to 20 tons 25% in excess

20 - 50 tons 5 tons in excess

Over 50 tons 10% in excess

(14) All lifting machines, ropes, chains and lifting tackles, except a fibre rope or fibre sling, which have been lengthened, altered or repaired by welding or otherwise, shall, before being again taken into use, be adequately re-tested and re-examined by a competent person and certificate of such test and examination be obtained, and particulars entered in the register kept in accordance with sub-rule (4).

(15) No person under 18 years of age and no person who is not sufficiently competent and reliable shall be employed as driver of a lifting machine whether driven by mechanical power or otherwise, or to give signals to a driver.

(16) Where the Competent Authority is satisfied that in a factory due to shutdown or for any other reasons it is not practicable to maintain a minimum distance of 6 metres between the person employed or working on or near the wheel track of a travelling crane and the crane, it may on the request of the manager reduce the distance to such extent as it may consider necessary and also prescribe further precautions indicating appointment of suitable number of supervisors to ensure the safety of the persons while they are employed or working on or near the track.

36. PRESSURE VESSELS OR PLANTS.-

(1) Interpretation.-In this rule-

(a) "design pressure" means the maximum pressure that a pressure vessel or plant is designed to withstand safely when operating normally;

(b) "maximum permissible working pressure" means the maximum pressure at which a pressure vessel or plant is permitted to be operated or used under this rule and is determined by the technical requirement of the process;

(c) "plant" means a system of piping that is connected to a pressure vessel and is used to contain a gas, vapour or liquid under pressure greater than the atmospheric pressure, and includes the pressure vessel;

(d) "pressure vessel" means a vessel that may be used for containing, storing, distributing, transferring, distilling, processing or otherwise handling any gas, vapour or liquid under pressure greater than the atmospheric pressure and includes any pipeline fitting or other equipment attached thereto or used in connection therewith; and

(e) "competent person" means a person as defined in Sr.No. 5. of schedule to rule 31.

(2) Exceptions.-Nothing in this rule shall apply to -

(a) vessels made of ferrous materials having an internal operating pressure not exceeding 1 kilogram per square centimeter;

(b) steam boilers, steam and feed pipes and their fittings coming under the purview of the Indian Boilers Act, 1923;

(c) metal bottles or cylinders used for storage or transport of compressed gases or liquefied or dissolved gases under pressure covered by the Gas Cylinder Rules, 1981 framed under the Indian Explosives Act, 1884;

(d) vessels in which internal pressure is due solely to the static head of liquid;

(e) vessels with a nominal water capacity not exceeding 500 litres connected in a water-pumping system containing air that is compressed to serve as a cushion;

(f) vessels for nuclear energy application shall be covered by rules framed by Competent Authority;

(g) refrigeration plant having a capacity of 3 tons or less of refrigeration in 24 hours; and

(h) working cylinders of steam engines or prime movers, feed pumps and steam traps; turbine casings; compressor cylinders; steam separators or dryers; steam strainers; steam de-super- heaters; oil separators; air receivers for fire sprinkler installations; air receivers of monotype machines provided the maximum working pressure of the air receiver does not exceed 130 kPa (1.33 kg/sq.cm) and the capacity 85 litres; air receivers of electrical circuit breakers; air receivers of electrical relays; air vessels on pumps, pipe coils, accessories of instruments and appliances such as cylinders and piston assemblies used for operating relays and interlocking type of guards; vessels with liquids subjected to static head only; and hydraulically operating cylinders other than any cylinder communicating with an air loaded accumulator.

(3) Design and construction.-Every pressure vessel or plant used in a factory -

(a) shall be properly designed on sound engineering practice;

(b) shall be of good construction, sound material, adequate strength and free from any patent defects; and

(c) shall be properly maintained in a safe working condition:

Provided that the pressure vessel or plant in respect of the design and construction of which there is an Indian standard or a standard of the country of manufacture or any other law or regulation in force, shall be designed and constructed in accordance with the said standards, law or regulation, as the case may be, and a certificate thereof shall be obtained from the manufacturer or from the competent person which shall be kept and produced on demand by an Inspector.

(4) Safety devices.-Every pressure vessel shall be fitted with-

(a) a suitable safety valve or other effective pressure relieving device of adequate capacity to ensure that the maximum permissible working pressure of the pressure vessel shall not be exceeded. It shall be set to operate at a pressure not exceeding the maximum permissible working pressure and when more than one protective device is provided, only one of the devices need be set to operate at the maximum permissible working pressure and the additional device shall be set to discharge at a pressure not more than 5 percent in excess of the maximum permissible working pressure;

(b) a suitable pressure gauge with a dial range not less than 1.5 times the maximum permissible working pressure, easily visible and designed to show at all times the correct internal pressure and marked with a prominent red mark at the maximum permissible working pressure of the pressure vessel;

(c) a suitable nipple and globe valve connected for the exclusive purpose of attaching a test pressure gauge for checking the accuracy of the pressure gauge referred to in clause (b) of this sub-rule;

(d) a suitable stop valve or valves by which the pressure vessel may be isolated from other pressure vessels or plant or source of supply of pressure. Such a stop valve or valves shall be located as close to the pressure vessel as possible and shall be easily accessible;

which shall be 1.5 times the maximum permissible working pressure:

Provided that the pressure vessel or plant which is so designed and constructed that it cannot be safely filled with water or liquid or is used in service when even some traces of water cannot be tolerated, shall be pneumatically tested at a pressure not less than the design pressure or maximum permissible working pressure as the case may be:

Provided further that the pressure vessel or plant which is lined with glass shall be tested hydrostatically or pneumatically as required at a pressure not less than the design pressure or maximum permissible working pressure as the case may be.

Explanation:- Design pressure shall be not less than the maximum permissible working pressure and shall take into account the possible fluctuations of pressure during actual operation.

(b) No pressure vessel or plant shall be used in a factory unless there has been obtained from the maker of pressure vessel or plant or from the competent person a certificate specifying the design pressure or maximum permissible working pressure thereof, and stating the nature of tests to which the pressure vessel or plant and its fittings (if any) have been subjected, and every pressure vessel or plant so used in a factory shall be marked so as to enable it to be identified as to be the pressure vessel or plant to which the certificate relates and certificate shall be kept available for perusal by the Inspector.

(c) No pressure vessel or plant shall be permitted to be operated or used at a pressure higher than its design pressure, or the maximum permissible working pressure as shown in the certificate.

(7) In-service test and examinations.-

(a) Every pressure vessel or plant in service shall be thoroughly examined by a competent person -

(i) externally, once in every period of six months; and

(ii) internally, once in every period of twelve months:

Provided that if by reason of the construction of a pressure vessel or plant, a thorough internal examination is not possible, this examination may be replaced by a hydrostatic test which shall be carried out once in every period of two years:

Provided further that for a pressure vessel or plant in continuous process which cannot be frequently opened, the period observations, findings and conclusions with other relevant remarks with reasons and may authorise the pressure vessel or plant to be used and kept in operation subject to a lowering of maximum permissible working pressure, or to more frequent or special examination or test, or subject to both of these conditions.

(b) A report of every examination or test carried out shall be completed in Form 5 and shall be signed by the person making the examination or test, and shall be kept available for perusal by the Inspector at all hours when the factory or any part thereof is working.

(c) Where the report of any examination under this rule specified any condition for securing the safe working of any pressure vessel or plant, the pressure vessel or plant shall not be used unless the specified condition is fulfilled.

(d) The competent person making report of any examination under this rule, shall within seven days of the completion of the examination, send to the Competent Authority a copy of the report in every case where the maximum permissible working pressure is reduced or the examination shows that the pressure vessel or plant or any part thereof cannot continue to be used with safety unless certain repairs are carried out or unless any other safety measure is taken.

(10) Application of other laws.-

(a) The requirements of this rule shall be in addition to and without any prejudice to and not in derogation of the requirements of any other law in force.

(b) Certificates or reports of any examination, or test of any pressure vessel or plant to which sub-rules (7) to (9) do not apply, conducted or required to be conducted under any other law in force and other relevant record relating to such pressure vessel or plant, shall be properly maintained as required under the said law and shall be produced on demand by the Inspector.

38. EXCESSIVE WEIGHTS.-

(1) No person, unless aided by another person or any mechanical device, shall carry or move by hand or head any material, article, tool or appliance exceeding the maximum limit in weight set out in the following Table:-

TABLE

Persons	Max. weight of material, article, tool or appliance in kg
a) Adult Male	55
b) Adult female	30

Provided that the dimensions of material, tool or appliance shall be such as not to make worker unstable and not to hurt others:

Provided further that pregnant females shall not be engaged for lifting loads.

(2) No female worker shall engage in conjunction with others, in lifting carrying or moving by hand or on head any material article, tool or appliance if the weight thereof exceeds the lowest weight fixed by Table to sub rule (1) above for any of the persons engaged multiplied by the persons engaged.

Rules -39

39. PROTECTION OF EYES.- Effective screens or suitable goggles shall be provided for the protection of persons employed in or in the immediate vicinity of the following processes, namely:-

(1) The processes specified in Schedule I to this rule, being processes which involve risk of injury to eyes from particles or fragments thrown off in the course of the processes.

(2) The processes specified in Schedule II to this rule, being processes which involve risk of injury to eyes by reason of exposure to excessive light or infra-red or ultra-violet radiations.

SCHEDULE I

INJURY TO EYE FROM PARTICLES

1. Breaking, cutting, dressing or carving of bricks, stone, concrete, slag or similar materials by means of a hammer, chisel, pick or similar hand tool, or by means of a portable tool driven by mechanical power, and the dry grinding of surfaces of any such materials by means of a wheel or disc driven by mechanical power, where in any of the foregoing cases, particles or fragments are liable to be thrown off towards the face of the operator in the course of the process.

2. Dry grinding of surfaces of metal by applying them by hand to a wheel, disc or band driven by mechanical power, and of surfaces of metal by means of a portable tool driven by mechanical power.

3. Dividing into separate parts of metal, bricks, stone, concrete or similar materials by means of a high speed saw driven by mechanical power or by means of an abrasive cutting-off wheel or disc driven by mechanical power.

4. Turning of metals or articles of metal, where particles or fragments are liable to be thrown off towards the face of the operator in the course of the process.

5. Drilling by means of portable tools, where particles or fragments are liable to be thrown off towards the face of the operator in the course of the process.

6. Welding and cutting of metals by means of an electric, oxy- acetylene or similar process.

7. Hot fettling of steel castings by means of a flux-injected burner or air torch, and de-seaming of metal.

8. Fettling of metal castings involving the removal of metal, including runners, gates and risers, and removal of any other material during the course of such fettling.

9. Chipping of metal, and chipping, knocking out, cutting out or cutting off of cold rivets, bolts, nuts, lugs, pins, collars or similar articles from any structure or plant, or from part of any structure or plant, by means of a hammer, chisel, punch or similar hand tool, or by means of a portable tool driven by mechanical power.

10. Chipping or scurfing of paint, scale, slag, rust or other corrosion from the surface of metal and other hard materials by means of a hand tool or by a portable tool driven by mechanical power.

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11. Breaking of scrap metal by means of a hammer or by means of a tool driven by mechanical power.

12. Routing of metal, where particles or fragments are liable to be thrown off towards the face of the operator in the course of the process.

13. Work with drop hammers and power hammers used in either case for the manufacture of forgings, and work by any person not working with such hammers, whose work is carried on in such circumstances and in such a position that particles or fragments are liable to be thrown off towards his face during work with drop hammers or power hammers.

14. Work at a furnace where there is risk to the eyes from molten metal.

15. Pouring or skimming of molten metal.

16. Work involving risk to the eyes from hot sand being thrown off.

17. Truing or dressing of an abrasive wheel.

18. Handling in open vessels or manipulation of strong acids or dangerous corrosive liquids or materials, and operation, maintenance or dismantling of plant or any part of plant being plant or part of plant which contains or has contained such acids, liquids or materials, unless the plant or part of plant has been so prepared (by isolation, reduction of pressure, or otherwise), treated, or designed and constructed as to prevent risk of injury.

19. Any other process wherein there is a risk of injury to eyes from particles or fragments thrown off during the course of the process.

SCHEDULE II

INJURY TO EYE FROM LIGHT AND RADIATION

1. Welding or cutting of metals by means of an electrical, oxy- acetylene or similar process.

2. All work on furnaces where there is risk of exposure to excessive light or infra-red radiations.

3. Process such as rolling, casting or forging of metals, where there is risk of exposure to excessive light heat or infra-red radiations.

4. Any other process wherein there is a risk of injury to eyes from exposure to excessive light or infra-red or ultra-violet radiations.

40. MINIMUM DIMENSIONS OF MANHOLES.- Every chamber, tank, vat, pipe, flue or other confined space, which persons may have to enter and which may contain dangerous fumes to such an extent as to involve risk of the persons being overcome thereby, shall unless there is other effective means of egress, be provided with a manhole which may be rectangular, oval or circular in shape, and shall have the following dimensions as minimum, namely:-

Rectangular shape- 50 cm X 30 cm

Oval shape - Major & minor axis diameters 50 cm. and 30 cm. respectively.

Circular shape - 50 cm diameter

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41. EXEMPTIONS.- The requirements of sub-section (4) of section 37 of the Act shall not apply to the following processes carried on in any factory, namely:-

(1) the operation of repairing a water sealed gasholder by the electric welding process, subject to the following conditions, namely:-

(a) the gasholder shall contain only the following gases, separately or mixed at a pressure greater than atmospheric pressure, namely, town gas, coke-oven gas, producer gas, blast furnace gas, or gases other than air, used in their manufacture:

Provided that this exemption shall not apply to any gasholder containing acetylene or mixture of gases to which acetylene has been added intentionally; and

(b) welding shall only be done by the electric welding process and shall be carried out by experienced operatives under the constant supervision of a competent person;

(2) the operations of cutting or welding steel or wrought iron gas mains and services by the application of heat, subject to the following conditions, namely:-

(a) the main or service shall be situated in the open air, and it shall contain only the following gases, separately or mixed at a pressure greater than atmospheric pressure, namely, town gas, coke-oven gas, producer gas, blast furnace gas, or gases other than air, used in their manufacture;

(b) the main or service shall not contain acetylene or any gas or mixture of gases to which acetylene has been added intentionally;

(c) the operation shall be carried out by an experienced person or persons and at least 2 persons (including those carrying out the operations) experienced in work on gas mains and over 18 years of age shall be present during the operation;

(d) the site of the operation shall be free from any flammable or explosive gas or vapour;

(e) where acetylene gas is used as a source of heat in connection with an operation, it shall be compressed and contained in a porous substance in a cylinder; and

(f) prior to the application of any flame to the gas main or service, this shall be pierced or drilled and the escaping gas ignited.

45. PLANNING OF BUILDING CONSTRUCTION & ROADS, SIDEWALKS.-

(1) General.- All constructions shall conform to National Building Code of Indian Standards Institution now Bureau of Indian Standards.*

(2) Means of access for industrial buildings.-

(a) Means of access for industrial buildings & those buildings which attract large crowd shall be adequate.

The length of the main access shall be determined by the distance from the farthest building to the public street. The length of the subsidiary accessories shall be measured from the point of its' origin to the next wider road on which it meets.

(b) Pathways: The approach to the buildings from road/street/internal means of access shall be adequate and through paved pathways.

(c) Intersection of Roads: For intersection junction of roads meeting at right angles as well as other than right angles, the rounding off or cut off or splay or similar treatment shall be done, depending upon the width of the roads, traffic, sighting angle etc. to provide clear sight distance.

(d) Speed Breakers & Pedestrian Passage: Speed breakers shall be provided on all roads which lead to main road near the junction. The pedestrian crossings shall be marked.

(e) Sign Boards & Signs: Sign boards displaying information on maximum permissible speeds and appropriate road signs wherever required shall be provided. The maximum permissible speed on internal roads shall be decided by the manager of the factory depending on the traffic, size and number of vehicles, number of persons working in a particular building etc. The sign boards, road signs & pedestrian crossings shall be of fluorescent paint. The speed limit on various roads shall be decided by the factory manager.

(3) Guarding of pits, sumps, trenches, manholes etc.-Pits, sumps, trenches, manholes and any other openings in the wall or floor shall be adequately covered or guarded. these shall be periodically checked and record maintained.

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* Note-The Code covers aspects of administrative regulations, development control rules & general building & fire protection requirements; rules for design of electrical, etc. installations; regulation for ventilation etc. & plumbing services; measures to ensure safety of workers & public during construction etc.

Rule - 46

46. CONSTRUCTION & ERECTION.-Manager shall take appropriate measures with the approval of the Inspector to minimise the effects of occupational hazards arising out of animals, reptiles, rodents, poisonous plants and weeds, weather conditions and living conditions.

(1) General.-

(a) Site preparation - While preparing the site for construction, bush and other wood, debris, etc, shall be removed and promptly disposed of so as to minimize the attendant hazards.

Temporary buildings for construction offices and storage shall be so located as to cause the minimum fire hazards and shall be constructed from non-combustible materials as far as practicable.

(b) Access for Fire Fighting Equipment & Vehicles - Access for fire fighting equipment shall be provided to the construction site at the start of construction and maintained until all construction work is completed:

(i) Free access from the street to fire hydrants/static water tanks, where available, shall be provided and maintained at all times;

(ii) No materials for construction shall be placed within 3m of hydrants/static water tanks; and

(iii) During building operations, free access to permanent, temporary or portable first-aid fire fighting equipment shall be maintained at all times.

(c) Access to the Upper Floors During Construction- In all buildings over two storeys high, at least one stairway shall be provided in usable condition at all times. This stairway shall be extended upward as each floor is completed. As far as possible, there shall be a handrail on the staircase.

(2) Storage, Stacking & Handling of Materials.-Construction of Plant and Building: Construction requires various kinds of materials such as cement; lime; masonary units; aggregate;. fly ash; timber; protective clothing; electrical fittings etc. These shall be stored and handled as per prevalent good practices & relevant national standards in order to ensure quality & quantity of materials used in the construction and safety of personnel handling these materials.

(3) Safety Requirements for Erection of Structural Steel Work.-

(a) Organization of Work - The agency responsible for erecting the steel work shall analyze the proposed erection scheme for safety. The erection scheme shall cover safety aspects right from the planning stage up to the actual execution of the work and make provision for personnel protective equipments.

(b) Safety of Men:

(i) General - Skilled workers trained in relevant jobs shall only be employed in jobs requiring skills.
(1) All personnel protective equipments like helmets, goggles, safety shoes, gloves, aprons etc. shall be suitable for the job & shall conform to relevant Indian Standards

(2) When the work is in progress, the area shall be cordoned off by barricades to structural components, or falling into excavated trenches or getting injured by falling objects.

(3) Warning signs shall be displayed where necessary to indicate hazards, for example (a) '440 VOLTS', (b) 'DO NOT SMOKE', (c) 'MEN WORKING AHEAD', etc.

(4) All electrically operated hand tools shall be provided with proper earthing.

(5) Hand lamps shall be of low voltage preferably 24 V to prevent electrical hazards.

(ii) Anchors for guys or ties shall be checked for proper placement. The weight of concrete in which the anchors are embedded shall be checked for uplift and sliding:

(1) Split-end eye anchors shall only be used in good, solid rock.

(2) The first load lifted by a guy derrick shall be kept at a small height for about 10 minutes and the anchors immediately inspected for any signs or indications of failure.

(3) When a number of trusses or deep girders are loaded in one car or on one truck, all but one being lifted shall be tied back unless they have been tied or braced to prevent their falling over and endangering men unloading.

(4) The erection gang shall have adequate supply of bolts, washers, rivets, pins, etc. of correct size. Enough number of bolts shall be used in connecting each piece using a minimum of two bolts in a pattern to ensure that the joint will not fail due to dead load and erection loads.

All splice connections in columns, crane girders, etc., shall be completely bolted or riveted or welded as specified in the drawing before erection.

(5) Safety belts shall always be provided & used for working at heights. The ropes shall be chemically treated to resist dew and rotting. These shall not be tied on sharp edges of steel structures. They shall be tied generally not more than 2 to 3 m. away from the belt.

(6) On a guy derrick or climbing crane job, the tool boxes used by the erection staff shall be moved to the new working floor each time the rig is changed. On a mobile crane job, the boxes shall be moved as soon as the crane starts operating in a new area too far away for the men to reach the boxes conveniently.

(7) Baskets or containers to hold small materials such as bolts and drift pins shall be provided to men working on floats or scaffolds. Men shall be trained to use such containers, and to keep small tools gathered up and put away in tool boxes when not in use. Material shall not be dumped overboard when a scaffold is to be moved. Rivet heaters shall have safe containers or buckets for hot rivets left over at the end of the day.

(8) During the erection of tall buildings, nylon nets at a height of 3 to 4 m. shall be provided to ensure safety of men if there is a fall from heights.

In case of industrial buildings the height of which is in excess of 4 m a temporary strong net shall be provided below the roof, at a height of 3 m to 4 m above the floor, over which workers are working.

(9) Safety Against Fire - A fire protection procedure shall be set up if there is to be any flame cutting, burning, heating, riveting or any operation that could start a fire. Following precautions shall be observed during welding and cutting operations.

(a) The workers shall be instructed not to throw objects like hot rivets, cigarette stubs, etc, around.

(b) Sufficient number of fire extinguishers, preferably of soda acid type shall be placed at strategic points. Extinguishers shall always be placed in cranes, hoists, compressors and similar places. Where electrical equipments are involved, CO2 or dry powder extinguishers shall be provided.

(10) Riding on a load, tackle or runner shall be prohibited.

(11) The load shall never be allowed to rest on wire ropes. Ropes in operation shall not be touched. Wire ropes/manila ropes conforming to acceptable standards shall be used for guying.

(12) Lifting Appliances - Necessary precautions as laid down in rule 37 shall be followed.

(c) Safety of Structure: General -The structure itself shall be safeguarded during its erection & erection of columns shall be immediately followed by vertical bracing between columns before the roof structure is erected.

(4) Excavation.-

(a) Excavation shall be planned in advance so that hazards due to falling and things falling are avoided. Accident prevention measures shall be adopted and effectively carried out on each job because of inherent dangers.

(b) Underground utilities such as water mains, drainage lines, electrical cables, gas lines etc. shall be located and protected wherever necessary.

(c) Adequate measures shall be taken to prevent dislodgement of loose or unstable earth, rock or other material from falling into the excavation by proper timbering.

(d) Cutting shall be done from top to bottom. Under no circumstances undermining or undercutting shall be done.

(e) No excavation below the level of any foundation of a building or structure (if the excavation is liable to effect the building) shall be commenced unless adequate shoring has been provided to prevent any danger to the building.

(f) In every excavation work along sloping ground, sides and slopes of ground shall be maintained in a safe condition by scaling, benching or barricading. Loose earth and loose rock shall be scaled continuously. To ensure safety of workers engaged on such work, each worker shall be provided with safety belt attached to a safety line. On steep slopes workers shall not be permitted to work one above the other. All such scaling work shall be done under good supervision.

(g) All trenches, 120 cm or more in depth, shall at all times be supplied with at least one ladder for each 30 meters in length or fraction thereof. Ladder shall be extended from bottom of the trench to at least one metre above the surface of the ground.

(h) Every accessible part on an excavation or an opening in the ground into which a person is liable to fall vertically through a height of 2 meters, shall be barricaded to a height of one metre.

(i) Measures shall be taken to prevent spectators and other workmen who are not engaged in excavation work, from approaching excavation areas by placing warning signals etc. near the site of the excavation. Provisions shall also be made to prevent animals from falling into excavation areas.

(5) Shoring.-

(a) Additional precautions by way of shoring and bracing shall be taken to prevent slides, slips or caveins when excavations or trenches are made in locations subject to vibrations from railway or road traffic, the operation of machinery or any other source of vibration.

(b) Excavation over 1.2 m in depth, unless in solid rock or hard soil shall be shored and braced or sloped to the angle of repose of the material when consolidated. All shoring and bracing shall extend to the bottom of the excavation when necessary.

(c) No person shall work in an excavation shaft, earth work of tunnel unless all timbering or planks used therein has been inspected by a competent person before the commencement of the work.

(6) Night work. –

(a) Excavated area shall be adequately lighted up for night work.

(b) During night, a red danger light shall be displayed at a conspicuous place near the excavation site to warn approaching traffic and men.

(7) Disposal of soil

The excavated material shall be dumped sufficiently away from the edge of the excavated trench to avoid the excavated material slipping and falling into the trench. The excavated materials and any other material or load shall not be dumped or placed within 1.5m of the edges of the trench or half of the depth of the trench whichever is more.

(8) Scaffolding:

(a) Suitable scaffolds shall be provided for workmen for all works that cannot be done safely from the ground.

(b) All the members of a scaffold such as planks, braces, vertical supports, horizontal supports shall be of sound material, good construction and of adequate strength. They shall be properly maintained.

(c) No plank shall be kept loose so that levering of the plank is avoided. Nails of proper size shall be used for construction of scaffolds in sufficient numbers and driven fully in.

(d) Scaffolding or staging more than 3.5 meters above the ground floor swung or suspended from an overhead support or erected with stationary support shall have a guard rail properly attached, bolted, braced and otherwise secured at least one metre high above the the floor or platform of such scaffolding or staging and extending along the entire length of the outside and ends thereof with only such opening as may be necessary for the delivery of materials. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the building or structure.

(e) On unprotected scaffolds at high elevations the men must wear life belts suitably anchored to some substantial part of the structure.

(f) Side screens shall be provided on scaffold erected along passageways.

(g) The platform of a suspended scaffold shall not be less than 45 cm. wide and points of suspension not more than 3 m apart and so arranged, that, at the working position, the edge is as close as practicable to the working face when persons have to work in a sitting position. Suspended scaffolds shall be tested as before use to ensure that minimum safety factors are maintained. The test will be made by raising the working surface 30 cm. above the ground and loading it with at least three times the maximum weight that will be imposed upon it.

(h) A safe and convenient means of access shall be provided to the platform or scaffold. Means of access may be a portable ladder, fixed ladder, ramp or a stairway. The use of cross braces or frame work as means of access to the working surface shall not be permitted.

(i) All scaffolds, before use, shall be examined by the engineer in charge.

(j) Every working place and approach thereto, every place where raising or lowering operations with the use of lifting appliance are in progress and all openings dangerous to persons employed shall be adequately and suitably lighted.

(k) During dismantling of scaffolds necessary precautions shall be taken to prevent injury to persons due to fall of loose materials.

(l) Bracings and other members of the scaffolds shall not be removed prematurely while dismantling the entire scaffold which shall be maintained stable and rigid so as to avoid the danger of collapse.

(m) Care shall be taken to see that no uninsulated electric wire exists within 3 metres of the working platform, gangways, runs, etc. of the scaffold.

(n) Good house-keeping shall be maintained at all times upon scaffolds, platforms and ramps. Excessive storage of materials thereon shall be avoided. Care must be taken to avoid accumulation of small objects such as tools, pieces of

(c) A man shall be specially employed as signalman to watch the movement of the bucket and warn the crew and vibrator operators of the approaching bucket so that all workers may clear out of the area affected by the bucket. Signalman shall be so stationed in a safe place that they can see the entire area where concrete is being placed.

(12) Work in open areas and specially at height shall be stopped under adverse weather conditions such as strong winds, snowfall, rainfall and under any other conditions specified by Safety Officer/Inspector.

47. TEMPORARY ELECTRICAL WIRING.-

(1) Frayed and / or bare wires shall not be used for temporary electrical connections during construction. All temporary wiring shall be installed and supervised by a competent electrician. Adequate protection shall be provided for all electrical wiring laid on floor which may have to be crossed over by construction machinery or by the workmen. All flexible wiring connecting the electrical appliances shall have adequate mechanical strength and shall preferably be enclosed in a flexible metal sheath. Overhead wires/cables shall be so laid that they leave adequate head room. Clearance for the above shall be obtained from the competent person.

(2) All electrical circuits, other than those required for illumination of the site at night, shall be switched off at the close of day's work. The main switch board from which connections are taken for lighting, power operated machinery, etc, shall be located in an easily accessible and prominent place. No article of clothing nor stores shall be kept at the back of or over the board or anywhere near it. One 3-kg/4.5-kg CO_2 extinguisher or one 5-kg dry powder extinguisher shall be provided near the switch board.

48. BUILDINGS & STRUCTURES.- No building, wall, chimney, bridge, tunnel, road, gallery, stairway, ramp, floor, platform, staging, or other structure, whether of a permanent or temporary character, shall be constructed, situated or maintained in any factory in such a manner as to cause risk of bodily injury.

49. MACHINERY AND PLANT.- No machinery, plant or equipment shall be constructed, situated, operated or maintained in any factory in such a manner as to cause risk of bodily injury or adverse effect on health. The Safety Officer shall have authority to stop the work if he finds that unsafe practices are being followed and/or unsafe conditions exist.

50. METHODS OF WORK.- No process or work shall be carried in any factory in such a manner as to cause risk of bodily injury. Schedule for Hand Tools & Portable Power Tools is given below.

SCHEDULE

HAND TOOLS & PORTABLE POWER TOOLS

1. Hand tools:-

   (a) Definition: Hand tool means any tool which is used without any external motive power.

   (b) Hand tools shall be of good quality materials, conforming to relevant BIS standards and shall be used only for the job it is designed for. Non sparking tools such as that made of Beryllium Copper alloy shall be used for working in explosive areas.

   (c) Workers shall be trained & instructed for proper use of tools such as files, hammers, hacksaws etc.

   (d) Proper tool bags shall be provided to workers to carry the tools and not leaving them on floors, passages etc.

   (e) Protective equipments such as gloves, goggles etc. shall be provided to and worn by the workers.

   (f) The tools shall be inspected regularly, repaired and maintained.

2. Portable Power Tools.-

   (a) Definition: Portable Power Tool means a tool powered by electric or pneumatic power, operated by a single operator and which is transportable from place to place.

   (b) Portable power tools shall conform to the relevant BIS standards and shall be used for the job it is designed for. Starting switches shall be located at such places where accidental starting cannot take place.

   (c) Electrically operated tools shall be used only with 3 core cable with proper earthing provided. This should be checked before use.

(d) Electrically operated tools shall not be used where flammable vapours, gases or dusts are present, unless they are specially designed for use in such environment.

(e) Proper guards shall be provided for tools such as grinders, saws etc. and operators shall be provided with personal protective equipments wherever required.

(f) In case of pneumatic tools a short chain shall be provided for attaching the air hose and tools housings securely to prevent it from whipping in case of breaking of the coupling.

(g) Periodic inspection and maintenance shall be carried out for electrical insulation, earthing, integrity etc.

51. STACKING AND STORING OF MATERIALS, ETC.- No materials or equipment shall be stacked or stored in such a manner as to cause risk of bodily injury.

52. LADDERS.-

(1) Every ladder shall be of good construction, sound material and of adequate strength for the purpose for which it is used. The rungs shall be parallel, level and uniformly spaced at 30 cm.

(2) Ladders shall be inspected regularly and repaired immediately. No ladder with defective or missing rungs shall be used. Wooden ladders shall not be painted. For preserving the material from deterioration linseed oil or clear varnish shall be used.

(3) No portable single ladder shall be over 9 m in length while the width between side rails in rung ladder shall in no case be less than 28 cm for ladder up to and including 3 m in length. For longer ladders this width shall be increased at least 20 mm for each additional metre of length. Uniform step spacing shall not exceed 30 cm.

(4) All ladders with spreading bases such as step and trestle ladders shall be equipped with rigid spreads or some other means to prevent their premature opening or closing.

(5) Ladders shall be in a safe position before being climbed. The best angle for a ladder is 75 with the horizontal i.e., the distance of the base of the ladder from the wall, pole structure etc., as the case may be shall be 1/4th its length.

(6) A ladder shall be stored upon brackets and in sheltered locations.

(7) A ladder shall not be placed upon a box, barrel, or other movable insecure object and against a round or angular pillar such as pipe or narrow steel section etc.

(8) Two ladders must not be spliced together as far as possible. When it is inevitable they shall be tied together properly to ensure rigidity. Extra parallel members at the point of splicing may be added to each of the main members of the ladder. Two ladders shall not be spliced together to provide access to a greater height than when a single ladder is used.

(9) Bamboo ladders shall be provided with twisted wire loops enclosing both longitudinal members to prevent them from opening outwards. However, such ladders where longitudinal members are reinforced with metal/wire loops shall not be used when working on electrical circuits.

(10) Metal ladders with insulating rubber shoes shall only be used for working with electrical lines or in places where they may come in contact with such wires.

(11) No worker shall work from a plank placed on the rungs of ladders.

(12) All permanently installed vertical ladders above a height of 3 m shall have manguards provided.

53. OVENS AND DRIERS.-

(1) Application - This rule shall apply to ovens and driers, except those used in laboratories or kitchens of any establishment and those which have a capacity below 325 litres.

(2) Definition:- For the purpose of this rule, "oven or drier" means any enclosed structure, receptacle, compartment or box which is used for baking, drying or otherwise processing of any article or substance at a temperature higher than the ambient temperature of the air in the room or space in which explosive mixture of air and a flammable substance is likely to be evolved within the enclosed structure, receptacle, compartment or box or part thereof on account of the article or substance which is baked, dried or otherwise processed within it.

(3) Separate electrical connection.- Electrical power supplied to every oven or drier shall be by means of a separate circuit provided with an isolation switch.

(4) Design, Construction, examination and testing.-

(a) Every oven or drier shall be properly designed on sound engineering practice and be of good construction, sound materials and adequate strength, free from any patent defects and safe if properly used.

(b) No oven or drier shall be taken into use in a factory for the first time unless a competent person has thoroughly examined all its parts and carried out the tests as are required to establish that the necessary safe systems and controls provided for safety in operation for the processes for which it is to be used and a certificate of such examination and tests signed by that competent person has been obtained and is kept available for inspection.

55. EXAMINATION OF EYE SIGHT OF CERTAIN WORKERS.-

(1) No person shall be employed to operate a crane, locomotive or fork-lift truck, or to give signals to a crane or locomotive operator unless his eyesight and colour vision have been examined and declared fit by a qualified ophthalmologist to work whether with or without the use of corrective glasses.

(2) The eye sight and colour vision of the person employed as referred to in clause 1 shall be examined at least once in every period of 12 months up to the age of 45 years and once in every 6 months beyond that age.

(3) Any fee payable for an examination of a person under this sub-rule shall be paid by the contractor/occupier and shall not be recoverable from that person.

(4) The record of examination or re-examination carried out as required under sub-rule 1 shall be maintained in Form-1.

57. QUALITY OF PERSONAL PROTECTIVE EQUIPMENT.-

All Personal Protective Equipment provided to workers as required under any of the provisions of the Act or the Rules shall conform to the relevant Indian Standards.

58. PROTECTIVE EQUIPMENT.- The Inspector may, having regard to the nature of the hazards involved in work and process being carried out, order the occupier or the manager in writing to supply to the workers exposed to particular hazard any personal protective equipment as may be found necessary.

59. THERMIC FLUID HEATERS.-

(1) All heaters shall be of such construction that coils are removable for periodic cleaning, visual inspection and hydraulic test.

(2) Suitable arrangements shall be made for cooling the furnace effectively in case of power failure.

(3) Before restarting the furnace, it shall be effectively purged.

(4) Velocity of flow of the thermic fluid shall not be allowed to fall below the minimum recommended by the manufacturers while the heater is in operation.

(5) The thermic fluid shall be circulated in a closed circuit formation with an expansion cum deaerator tank. This tank shall be located outside the shed where the heater is installed.

(6) Every heater shall be provided with a Photo-resistor actuated audio-visual alarm to indicate flame failure and automatic burner cut off.

(7) The stack temperature monitor-cum-controller with audio- visual alarm shall be provided so as to warn the operator in case the outlet temperature exceeds the specified minimum.

(8) Where inspection doors are provided on the furnace they shall be interlocked with the burner itself so that they cannot be opened until burner is shut off and furnace is cooled sufficiently.

(9) All heaters shall also be provided with the following safety devices:-

(a) level control in the expansion tank;

(b) temperature control of thermic fluid;

(c) differential pressure switch on the outlet line of the heater tubes; and

(d) temperature control device for the fuel oil supply to the burner.

(10) All evices mentioned in sub-rule (9)shall have interlocking arrangement with burner so that in case of any predetermined limits being crossed the supply of fuel and air to burner shall automatically be cut-off.

(11) All safety interlocks when operated shall be indicated on the control panel of the heater by a suitable audio visual alarm.

(12) Every heater unit shall be provided as a standard accessory an arrangement for sniffing with low pressure steam or nitrogen for putting out the fire.

(13) Electric panel for the heater shall be located near the heater but not so close as to be exposed to spilling or leaking oil.

(14) The heater shall be located in a place segregated from other manufacturing activities.

(15) Explosion vent shall be so installed that release takes place at safe location.

(16) The heater oil shall be subjected to pressure test by competent person once at least in every 12 months. The test pressure shall not be less than twice the operating pressure.

(17) If repairs are carried out to the coil, it shall be tested before taking it into use.

(18) The thermic fluid shall conform to the specifications prescribed by the manufacturer and shall be tested by competent person for suitability at least once in every three months period. Such tests shall include test for acidity, suspended matter, ash contents, viscosity and flash point.

(19) Cleaning of the internal surface of the heater or soot and check up of refractory surface on the inside shall be carried out every month or as often as required depending upon working conditions. The coils shall be removed and surface of the coils cleaned thoroughly once at least in a period of six months. The burner, nozzles, oil filters and pumps shall be cleaned once a week during the period of use.

(20) A separate register containing the following information shall be maintained,-

(a) weekly checks carried out confirming the effectiveness of the interlock;

(b) weekly checks confirming that all accessories are in good state of repairs; and

(c) information regarding fuel oil temperature, pressure, thermic fluid inlet/outlet pressure and temperature, fuel gas temperature, recorded at 4 hourly interval.

(21) The heater when in operation shall always be kept in charge of a trained operator.

60. RECORD KEEPING & ANNUAL REVIEW.-Each factory shall maintain a record of field equipment failures and Failure Mode, Effect & Criticality Analysis in prescribed Forms 7 & 8 respectively. This data and analysis shall be used for preparation of preventive maintenance schedules and prevention of potential hazards. In addition, the factory shall conduct an annual review of unusual occurrences and accidents occurred and submit the report to the Competent Authority.

61. COLOUR CODING OF SERVICE LINES.-

(1) Pipelines for water, air, oil and gases shall be colour coded as per Indian Standard: 2379-1963 & Indian Standard: 5-1978.

(2) Electrical conduit panels shall be colour coded as per Indian Standard: 375-1951 & Indian Standard: 5-1978.

62. HAZARDOUS CHEMICALS.- The occupier of every factory involving hazardous process shall fill the Form 9 entitled `Material Safety Data Sheet' and inform all employees of the factory, and the Competent Authority about the hazards involved. The Competent Authority may, on the basis of Material Safety Data Sheet mentioned above direct the Manager in writing to supply the workers exposed to particular hazard any necessary personal protective equipment conforming to relevant Indian Standards and prescribe the information and manner in which this information is to be passed on to the general public residing in the vicinity of the factory.

Rule 63

CHAPTER V

WELFARE

63. WASHING FACILITIES.-

(1) There shall be provided and maintained, in every factory for the use of employed persons adequate and suitable facilities for washing which shall include soap and nail brushes or other suitable means of cleaning and the facilities shall be conveniently accessible and shall be kept in a clean and orderly condition.

(2) Without prejudice to the generality of the foregoing provisions, the washing facilities shall include-

(a) a trough with taps or jets at intervals of not less than 60 cm.; or

(b) wash basins with taps attached there to;or

(c) taps on stand-pipes; or

(d) showers controlled by taps; or

(e) circular troughs of fountain type:

Provided that the Inspector may having regard to the needs and habits of the workers, fix the proportion in which the aforementioned types of facilities shall be installed.

(3) (a) Every trough and basin shall have a smooth, impervious surface and shall be fitted with a waste-pipe and plug.

(b) The floor or ground under and in the immediate vicinity of every trough, tap, jet, wash-basin, stand-pipe, and shower shall be so laid or finished as to provide a smooth impervious surface and shall be adequately drained.

(4) For persons whose work involves contact with any injurious or noxious substance there shall be at least one tap for every fifteen persons, and for persons whose work does not involve such contact the number of taps shall be as prescribed in the Schedule given below.

SCHEDULE

Number of workers **(1)**	Number of taps **(2)**
Up to 20	1
21 to 35	2
36 to 50	3
51 to 150	4
151 to 200	5

(1)	(2)
Exceeding 200 but not exceeding 500	5 plus one tap for every 50 or fraction of 50
Exceeding 500	11 plus one tap for every 100 or fraction there of 100

(5) If female workers are employed, separate washing facilities shall be provided and so enclosed or screened that the interiors are not visible from any place where persons of other sex work or pass. The entrance to such facilities shall bear conspicuous notice "For Women Only" in the language understood by the majority of the workers and shall also be indicated pictorially.

(6) The water supply to the washing facilities shall be capable of yielding at least 27 litres a day for each person employed in the factory and shall be from a source approved in writing by the Medical Officer if the source of supply is not the same as for drinking water:

Provided that where the Competent Authority is satisfied that such an yield is not practicable he may by certificate in writing permit the supply of a smaller quantity not being less than 5 litres per day for every person employed in the factory.

64. FACILITIES FOR KEEPING CLOTHING.- All classes of factories mentioned in the Schedule to this rule shall provide facilities for keeping clothing not worn during working hours. Such facilities shall include the provision of arrangements approved by the Competent Authority. The Competent Authority shall have powers to add other factories under the Schedule given below:-

SCHEDULE

Chemical works.

Engineering workshops.

Glass works.

Automobile workshops.

Power Plants.

5. FIRST-AID AND FIRST-AID APPLIANCES.- The first-aid oxes or cupboards shall be distinctively marked with a red cross on white background and shall contain the following equipments, namely :-

(1) The manager of the factory shall lay down procedures for First-Aid and medical services

so that injured or ill person receives prompt attention or aid. The person here means, a worker of the factory, contractor's labour or even a visitor.

(2) For factories in which the number of persons employed does not exceed ten, or in the case of factories in which mechanical power is not used & the number of persons does not exceed fifty each first-aid box or cupboard shall contain the following equipments, namely:-

(a) Six small size sterilised dressings.

(b) Three medium size sterilised dressings.

(c) Three large size sterilised dressings.

(d) Three large size sterilised burn dressings.

(e) One (60 ml) bottle of centrimide solution (1%) or a suitable antiseptic solution.

(f) One (60 ml) bottle of mercury chrome solution (2%) in water.

(g) One (30 ml) bottle containing sal-volatile having the dose and mode of administration indicated on the label.

(h) One pair of scissors.

(i) One roll of adhesive plaster (2 cm X 1 m).

(j) Six pieces of sterilised eye pads in separate sealed packets.

(k) A bottle containing 100 tablets (each of 325 mg) of aspirin or any other analgesic.

(l) Polythene wash bottle (1/2 litre, i.e. 500 cc) for washing eyes.

(m) A snake-bite lancet.

(n) One (30 ml) bottle containing potassium permanganate crystals.

(o) One tourniquet.

(p) A supply of suitable splints, and

(q) One copy of First-Aid leaflet issued by the Competent Authority.

(3) For factories in which mechanical power is used and in which the number of persons employed exceeds ten but does not exceed fifty, each first-aid box or cupboard shall contain the following equipments, namely:-

(a) Double of the quantity as indicated in respect of items (a) to (g) of sub-rule (2) above.

(b) Six (15 gms) packets of sterilized cotton wool.

(c) One pair of scissors.

(d) Two rolls of adhesive plaster (2 cm X 1 m).

(e) Eight pieces of sterilized eye pads in separate sealed packets.

(f) One tourniquet.

(g) A supply of suitable splints.

(h) One dozen safety pins.

(i) A bottle containing 100 tablets (each of 325 mg) of aspirin or any other analgesic.

(j) One polythene wash bottle (1/2 litre i.e., 500 cc) for washing eyes.

(k) A snake-bite lancet.

(l) One(30 ml) bottle containing potassium permanganate crystals.

(m) One copy of the first-aid leaflet issued by the Competent Authority.

(4) For factories employing more than fifty persons, each First-Aid box or cupboard shall contain the following equipments, namely:-

(a) Double of the quantity as indicated in respect of items (a) to (e) of sub-rule (2) above.

(b) One (200 ml) bottle of centrimide solution(1%) or a suitable antiseptic solution.

(c) One (200 ml) bottle of mercury chrome (2%) solution in water

(d) One (120 ml) bottle of sal-volatile having the dose and mode of administration indicated on the label.

(e) One pair of scissors.

(f) One roll of adhesive plaster (6 cm X 1 m).

(g) Two rolls of adhesive plaster (2 cm X 1 m).

(h) Twelve pieces of sterilized eye pads in separate sealed packets.

(i) A bottle containing 100 tablets (each of 325 mg) of aspirin or any other analgesic.

(j) One polythene wash bottle (500 cc) for washing eyes.

(k) Twelve roller bandages 10 cm wide.

(l) Twelve roller bandages 5 cm wide.

(m) Six triangular bandages.

(n) One tourniquet.

(o) A supply of suitable splints.

(p) Two packets of safety pins.

(q) Kidney tray.

(r) A snake-bite lancet.

(s) One(30 ml) bottle containing potassium permanganate crystals.

(t) One copy of first-aid leaflet issued by the Competent Authority:

Provided that items (j) to (q) inclusive, need not be included in the standard first-aid box or cupboard where there is a properly equipped ambulance room, or if at least one box containing such items placed and maintained in accordance with the requirements of section 45 is separately provided:

Provided further that the medical officer of the factory may alter the type and quantity of the contents at his discretion. The list of contents shall, however, be pasted inside the first aid box.

(5) In lieu of the dressings required under items (a) and (b), these may be substituted by adhesive wound dressings approved by the Competent Authority and other equipment or medicines that may be considered essential and recommended by the Competent Authority from time to time.

66. NOTICE REGARDING FIRST-AID.- A notice containing the names of the persons working within the precincts of the factory who are trained in first-aid treatment and who are in charge of the first-aid boxes or cupboards shall be posted in every factory at a conspicuous place and near each such box or cupboard. The notice shall also indicate workroom where the said person shall be available. The name of the nearest hospital and its telephone number shall also be mentioned prominently in the said notice.

67. AMBULANCE ROOM.-

(1) Every ambulance room shall be under the charge of at least one whole-time qualified medical practitioner (hereinafter referred to as medical officer) who shall be assisted by at least one qualified nurse or dresser-cum-compounder and one nursing attendant in each shift. The medical officer shall be readily available on call during working hours of the factory:

Provided that where a factory works in more than one shift, the Competent Authority, if it is satisfied that on account of the size of the factory, nature of hazards or frequency of accidents, it is necessary to employ a whole time medical officer for each shift separately, may, order so in writing.

(2) There shall be displayed in the ambulance room a notice giving the name, address and telephone number of the medical practitioner in charge. The name of the nearest hospital and its telephone number shall also be mentioned prominently in the said notice.

(3) No medical officer shall be required or permitted to do any work which is inconsistent with or detrimental to his responsibilities under this rule.

(4) The ambulance room shall be separate from the rest of the factory and shall be used only for the purpose of first-aid treatment and rest. It shall have a floor area of at least 24 sq.m. and smooth, hard and impervious walls and floors, and shall be adequately ventilated and lighted by both natural and artificial means. There shall be attached to it at least one latrine & urinal of sanitary type. An adequate supply of wholesome drinking water shall be laid on and the room shall contain at least the following, namely:-

(a) A glazed sink with hot and cold water always available.

(b) A table with a smooth top at least 180 cm X 105 cm.

(c) Means for sterilizing instruments.

(d) A couch.

(e) Two stretchers.

(f) Two buckets or containers with close fitting lids.

(g) Two rubber hot water bags.

(h) A kettle and spirit stove or other suitable means of boiling water.

(i) Twelve plain wooden splints 900 mm X 100 mm X 6 mm.

(j) Twelve plain wooden splints 350 mm X 75 mm X 6 mm.

(k) Six plain wooden splints 250 mm X 50 mm X 12 mm.

(l) Six woolen blankets.

(m) Three pairs of artery forceps.

(n) One bottle of spiritus ammoniac aromaticus (120 ml)

(o) Smelling salts (60 gm).

(p) Two medium size sponges.

(q) Six hand towels.

(r) Four "Kidney" trays.

(s) Four cakes of toilet, preferably antiseptic soap.

(t) Two glass tumblers and two wine glasses.

(u) Two clinical thermometers.

(v) Two tea spoons.

(w) Two graduated (120 ml) measuring glasses.

(x) Two minim measuring glasses.

(y) One wash bottle (1000 cc) for washing eyes.

(z) One bottle (one litre) carbolic lotion 1 in 20.

(aa) Three chairs.

(bb) One screen.

(cc) One electric hand torch.

(dd) Four first-aid boxes or cupboards stocked to standards prescribed under(c)of rule 59.

(ee) An adequate supply of anti-tetanus toxiod.

(ff) Injections - morphia, pethidrine, atropine, adrenaline, coramine, novocain (6 each).

(gg) Coramine liquid (60 ml).

(hh) Tablets -25 each of antihistaminic, antispasmodic.

(ii) Syringes with needles - 2 cc, 5 cc, 10 cc and 50 cc.

(jj) Three surgical scissors.

(kk) Two needle holders, big and small.

(ll) Suturing needles and materials.

(mm) Three dissecting forceps.

(nn) Three dressing forceps.

(oo) Three scalpels.

(pp) One stethoscope.

(qq) Rubber bandage - pressure bandage.

(rr) Oxygen cylinder with necessary attachments.

(5) The occupier of every factory to which these rules apply shall for the purpose of removing serious cases of accidents or sickness, provide in the premises and maintain in good condition a suitable conveyance unless he has made arrangements for obtaining such a conveyance from a hospital.

(6) The Competent Authority may, by an order in writing exempt any factory from the requirements of this rule, subject to such conditions as it may specify in that order, if a hospital, ambulance room or dispensary is maintained at or within 200 m. of the precincts of the factory and such arrangements are made as to ensure the immediate treatment of all injuries sustained by workers within the factory and for providing rest to the workers so injured.

Explanation:- For the purpose of this rule, "qualified medical practitioner" means a person holding a qualification granted by an authority specified in the schedule to the Indian Medical Degrees Act, 1916 (7 of 1916), or in the schedules to the Indian Medical Council Act, 1956 (102 of 1956).

Rules -68

68. CANTEENS.-

(1) The occupier of every factory where in more than two hundred and fifty workers are ordinarily employed shall provide in or near factory an adequate canteen according to standard prescribed in these rules.

(2) The canteen building shall be situated not less than 15 meters from any boiler house, coal stacks, ash dumps and any other source of dust, smoke or obnoxious fumes:

Provided that the Competent Authority may in any particular factory relax the provisions of this sub-rule to such an extent as may be reasonable in the circumstances and may require measures to be adopted to secure the essential purpose of this sub-rule.

(3) The canteen building shall be constructed in accordance with the plans and shall accommodate at least a dining hall, kitchen, store room, pantry and washing places separately for workers and for utensils.

(4) In a canteen the floor and inside walls up to a height of 1.2 metres from the floor shall be made of smooth and impervious material; the remaining portion of the inside walls shall be made smooth by cement plaster or in any other manner.

(5) The doors and windows of a canteen building shall be of flyproof construction and shall allow adequate ventilation.

(6) The canteen shall be sufficiently lighted at all times when any persons have access to it.

(7) (a) In every canteen -

(i) all inside walls of rooms and all ceilings and passages and staircases shall be limewashed or colourwashed at least once in each year or painted once in three years dating from the period when last limewashed, colourwashed or painted, as the case may be;

(ii) all wood work shall be varnished or painted once in three years dating from the period when last varnished or painted; and

(iii) all internal structural iron or steel work shall be varnished or painted once in three years dating from the period when last varnished or painted:

Provided that inside walls of the kitchen shall be limewashed once every four months.

(b) Records of dates on which lime washing, colourwashing, varnishing or painting is carried out shall be maintained in the prescribed register (Form 2).

(8) The precincts of the canteen shall be maintained in a clean and sanitary condition. Waste water shall be carried away in suitable covered drains and shall not be allowed to accumulate so as to cause a nuisance. Suitable arrangements shall be made for the collection and disposal of garbage.

69. DINING HALL.-

(1) The dining hall shall accommodate at a time at least 30 per cent of the workers working at a time and shall be provided with adequate numbers of tables and chairs or benches:

Provided that, in any particular factory or in any particular class of factories, the Competent Authority may by a notification in this behalf alter the percentage of workers to be accommodated.

(2) The floor area of the dining hall, excluding the area occupied by the service counter and any furniture except tables and chairs, shall be not less than 1 sq.m per diner to be accommodated as prescribed in sub-rule (1).

(3) A portion of the dining hall and service counter shall be partitioned off and reserved for women workers in proportion to their number. Washing places for women shall be separate and screened to secure privacy.

70. EQUIPMENT.-

(1) There shall be provided and maintained sufficient utensils, crockery, cutlery, furniture and any other equipment necessary for the efficient running of the canteen. Suitable clean clothes for the employees serving in the canteen shall also be provided and maintained.

(2) The furniture, utensils and other equipment shall be maintained in a clean and hygienic condition. A service counter, if provided, shall have a top of smooth and impervious material. Suitable facilities including an adequate supply of hot water shall be provided for the cleaning of utensils and equipment.

71. ANNUAL MEDICAL EXAMINATION.-

(1) Annual medical examination for fitness of each member of the canteen staff who handles foodstuffs shall be carried out by the factory medical officer or the Certifying Surgeon, which should include the following, namely:-

(a) routine blood examination;

(b) routine and bacteriological testing, of faeces and urine for germs of dysentery and typhoid fever; and

(c) any other examination including chest X-ray that may be considered necessary by the factory medical officer or the Certifying Surgeon.

(2) Any person who in the opinion of the factory medical officer or the certifying surgeon is unsuitable for employment on account of possible risk to the health of others, shall not be employed as canteen staff.

Rule 72

72. SHELTERS, REST ROOMS AND LUNCH ROOMS.-

(1) The shelters, or rest rooms and lunch rooms shall conform to the following standards, namely:-

(a) the building shall be soundly constructed and all the walls and roof shall be of suitable heat resisting materials and shall be water-proof. The floor and walls to a height of 90 cm. shall be so laid or finished as to provide a smooth, hard impervious surface;

(b) the height of every room in the building shall be not less than 3.70 m from floor level to the lowest part of the roof and there shall be at least 1.10 sq.m of floor area for every person employed:

Provided that (i) workers who habitually go home for their meals during the rest periods may be excluded in calculating the number of workers to be accommodated, and (ii) in the case of factories in existence at the date of commencement of the Act, where it is impracticable owing to lack of space to provide 1.10 sq.m. of floor area for each person, such reduced floor area per person shall be provided as may be approved in writing by the Competent Authority;

(c) effective and suitable provision shall be made in every room for securing and maintaining adequate ventilation by the circulation of fresh air and there shall also be provided and maintained sufficient and suitable natural or artificial lighting;

(d) every room shall be adequately furnished with chairs or benches with back-rest; and

(e) sweepers shall be employed whose primary duty it is to keep the rooms, building and precincts thereof in a clean and tidy condition.

(f) suitable provision shall be made in every room for supply of drinking water and facilities for washing.

(2) The lunch rooms shall -

(a) comply with the requirements laid down in clauses (a) to (f) of sub-rule (1), and

(b) be provided with adequate number of tables with impervious tops for the use of workers for taking food:

Provided that the Competent Authority may exempt any factory from the provisions of this rule subject to the provisions being complied by some other means.

73. CRECHES.-

(1) The creche shall be conveniently accessible to the mothers of the children accommodated therein and so far as is reasonably practicable it shall not be situated in close proximity to any part of the factory where obnoxious fumes, dust or odours are given off or in which excessively noisy processes are carried on.

(2) The building in which the creche is situated shall be soundly constructed and all the walls and roof shall be of suitable heat resisting materials and shall be water-proof. The floor and internal walls of the creche shall be so laid or finished as to provide a smooth impervious surface.

(3) The height of the rooms in the building shall be not less than 3.70 m from the floor to the lowest part of the roof and there shall be not less than 2.00 sq.m of floor area for each child to be accommodated.

(4) Effective and suitable provision shall be made in every part of the creche for securing and maintaining adequate ventilation by the circulation of fresh air.

(5) The creche shall be adequately furnished and equipped and in particular there shall be one suitable cot or cradle with the necessary bedding for each child (provided that for children over two years of age it will be sufficient if suitable bedding is made available), at least one chair or equivalent seating accommodation for the use of each mother while she is feeding or attending to her child, and a sufficient supply of suitable toys for the older children.

(6) A suitably fenced and shady open air playground shall be provided for the older children:

Provided that the Competent Authority may by order in writing exempt any factory from compliance with this sub-rule if he is satisfied that there is not sufficient space available for the provision of such a play-ground.

74. WASHROOM.-

(1) There shall be in or adjoining the creche a suitable washroom for the washing of the children and their clothing. The washroom shall conform to the following standards, namely:-

(a) the floor and internal walls of the room to a height of 90 cm. shall be so laid or furnished as to provide a smooth impervious surface. The room shall be adequately lighted and ventilated and the floor shall be effectively drained and maintained in a clean and tidy condition;

(b) there shall be at least one basin or similar vessel for every four children accommodated in a creche at any one time together with a supply of water provided, if practicable, through taps from a source approved by the Health Officer. Such source shall be capable of yielding for each child a supply of at least 23 litres of water a day; and

(c) an adequate supply of clean clothes, soap and clean towels shall be made available for each child while it is in the creche.

(b) there shall be at least one basin or similar vessel for every four children accommodated in a creche at any one time together with a supply of water provided, if practicable, through taps from a source approved by the Health Officer. Such source shall be capable of yielding for each child a supply of at least 23 litres of water a day; and

(c) an adequate supply of clean clothes, soap and clean towels shall be made available for each child while it is in the creche.

(2) Adjoining the washroom referred to in sub-rule (1), a latrine shall be provided for the sole use of the children in the creche. The design of latrine and the scale of accommodation to be provided shall either be approved by the Public Health authorities or, where there is no such Public Health authority, by the Competent Authority.

75. SUPPLY OF MILK AND REFRESHMENT.-At least a quarter litre of clean pure milk shall be available for each child on every day if accommodated in the creche and the mother of such a child shall be allowed in the course of her daily work, four intervals of at least 15 minutes to feed the child. For children above two years of age there shall be provided in addition an adequate supply of wholesome refreshment.

76. CRECHE STAFF.- For each creche there shall be appointed a woman in-charge and an adequate number of female attendants to help the woman in-charge. No woman in-charge shall be appointed under this rule unless she possesses the qualifications prescribed for a midwife or produces a certificate that she has undergone training for a period of not less than 18 months in a hospital, maternity home or nursing home approved in this behalf by the Competent Authority or produces a certificate that she has received training for a pre-primary teacher in an institution approved by the State Government. The creche staff shall be provided with suitable clean clothes for use while on duty in the creche.

77. EXEMPTION FROM THE PROVISION OF CRECHE.-

(1) In factories where the number of married women or widows employed does not exceed 15 or where the factory works for less than 180 days in a calendar year, or where number of children kept in the creche was less than 5 in the preceding year, the Competent Authority may exempt such factories from the provisions of section 48 and the rules 73 to 76 made thereunder, if he is satisfied that alternate arrangements as stipulated under subrule (2) are provided by the factory.

(2) (a) The alternate arrangements required in sub-rule (1) shall include a creche building which has a minimum accommodation at the rate of 1.90 sq. m. per child and constructed in accordance with the plans approved by the Competent Authority.

(b) The creche building shall have -

(i) a suitable washroom for washing of the children and their clothing;

(ii) adequate supply of soap and clean clothes and towels; and

(iii) adequate number of female attendants who are provided with suitable clean clothes for use while on duty to look after the children in the creche.

(3) The exemption granted under sub-rule (1) may at any time be withdrawn by the Competent Authority if it finds after such enquiry as he may deem fit, that the factory has committed a breach of this rule.

Rules -78

78. WELFARE OFFICER.-

(1) Number of Welfare Officers.-

(a) The occupier of every factory employing between five hundred(500) and two thousand (2000) workers shall appoint at least one Welfare Officer, and where the number of workers exceeds 2000, there shall be an additional Welfare Officer for every additional 2000 workers or fraction thereof over 500. In a factory where both men and women workers are employed, the number of women Welfare Officers to be appointed shall be in proportion to the women workers employed provided that where the number of women employed is more than 100 and the total number of workers does not exceed 2500 an additional woman Welfare Officer shall be appointed.

(b) Where there are more than one Welfare Officer appointed, one of them shall be called the Chief Welfare Officer and the others Assistant Welfare Officers.

(2) Qualifications.- A person shall not be eligible for appointment as a Welfare Officer, unless he -

(a) possesses a degree of a University recognised by the Government in this behalf;

(b) has obtained a degree or diploma in social science with specialization in industrial relations from any institution recognised by the Government in this behalf; and

(c) has adequate knowledge of the language spoken by the majority of the workers in the factory to which he is to be attached:

Provided that the Competent Authority, may by notification grant exemption from the provisions of clause (b) in suitable cases till such time as qualified persons are available:

Provided further that, in the case of a person who is acting as a Welfare Officer at the commencement of these rules, the Competent Authority may, subject to such conditions as it may specify, relax all or any of the aforesaid qualifications.

(3) Appointment of Welfare Officers.-

(a) The appointment of welfare officers shall be done as per the extant government procedures.

(b) The appointment when made shall be notified by the occupier to the Competent Authority or such authority as the Competent Authority may specify for the purpose, giving full details of the qualifications, etc. of the officer appointed and the conditions of his service.

(4) Conditions of service of Welfare Officers.-

(a) A Welfare Officer shall be given appropriate status corresponding to the status of the other executive heads of the factory and he shall be started on a suitable scale of pay equivalent to that of group B officer, the minimum of which shall not be less than Rs.2000/- per month.

(b) The conditions of service of a Welfare Officer shall be the same as of other members of the staff of corresponding status in the factory.

(5) Duties of Welfare Officer.- The duties of a Welfare Officer shall be -

(a) to establish contacts and hold consultations with a view to maintaining harmonious relations between the factory management and workers;

(b) to bring to the notice of the factory management the grievances of workers, individual as well as collective, with a view of securing their expeditious redress and to act as a liaison officer between the management and labour;

(c) to study and understand the point of view of labour in order to help the factory management to shape and formulate labour policies and to interpret these policies to the workers in a language they can understand;

(d) to watch industrial relations with a view of using his influence in the event of a dispute between the factory management and workers and to help to bring about a settlement by persuasive effort;

(e) to advise on fulfillment by the management and the concerned departments of the factory of obligations, statutory or otherwise, concerning regulation of working hours, maternity benefit, medical care, compensation for injuries and sickness and other welfare and social benefit measures;

(f) to advise and assist the management in the fulfillment of its obligations, statutory or otherwise, concerning prevention of personal injuries and maintaining a safe work environment, in such factories where a Safety Officer is not required to be appointed under the enabling provisions under section 40 B;

(g) to promote relations between the concerned departments of the factory and workers which will bring about productive efficiency as well as amelioration in the working conditions and to help workers to adjust and adapt themselves to these working environments;

(h) to encourage the formation of Works and Joint Production Committees, Co-operative Societies and Welfare Committee, and to supervise their work;

(i) to encourage provision of amenities such as canteens, shelters for rest, creches, adequate latrine facilities, drinking water, sickness and benevolent scheme payments, pension and superannuation funds, gratuity payments, granting of loans and legal advice to workers;

(j) to help the factory management in regulating the grant of leave with wages and explain to the workers the provisions relating to leave with wages and other leave privileges and to guide the workers in the matter of submission of application for grant of leave for regulating authorised absence;

(k) to advise on provision of welfare facilities, such as housing facilities, foodstuffs, social and recreational facilities, sanitation, advice on individual personnel problems and education of children;

(l) to advise the factory management on questions relating to training of new starters, apprentices, workers on transfer and promotion, instructors and supervisors, supervision and control of notice board and information bulletins to further education of workers and to encourage their attendance at technical institutes; and

(m) to suggest measures which will serve to raise the standard of living of workers and in general promote their well- being.

(6) Welfare Officers not to deal with disciplinary cases or appear on behalf of the management against workers.- No Welfare Officer shall deal with any disciplinary cases against workers or appear before a conciliation officer in a court or tribunal on behalf of the factory management against a worker or workers.

(7) Powers of exemption.- The Competent Authority may, by notification exempt any factory or class or description of factories from the operation of all or any of the provisions of this chapter, subject to compliance with such alternative arrangements as may be approved by such Competent Authority.

Rule 88 (Sch. -X)

SCHEDULE X

FINISHING BY ABRASIVES PROPELLED BY COMPRESSED AIR/STEAM

Cleaning or Smoothening, Roughening, etc., of Articles, by a Jet of Sand, Metal Shot, or Grit, or other Abrasive Propelled by a Blast of Compressed Air or Steam:

1. Definition.- For the purposes of this Schedule

   (a) "blasting" means cleaning, smoothening, roughening, or removing of any part of the surface of any article by the use as an abrasive of a jet of sand, metal shot, or grit or other material, propelled by a blast of compressed air or steam;

   (b) "blasting enclosure" means a chamber, barrel, cabinet or any other enclosure designed for the performance of blasting therein;

   (c) "blasting chamber" means a blasting enclosure in which any person may enter at any time in connection with any work or otherwise; and

   (d) "cleaning of castings" where done as an incidental or supplemental process in connection with the making of metal castings, means the freeing of the casting from adherent sand or other substance and includes the removal of cores and the general smoothening of a casting, but does not include the free treatment.

2. Prohibition of sand blasting.- Sand or any other substance containing free silica shall not be introduced as an abrasive into any blasting apparatus and shall not be used for blasting:

   Provided further that no woman shall be employed or permitted to work at any operation of sand blasting.

3. Precautions in connection with blasting operations.-

   (a) Blasting shall not be done except in a blasting enclosure and no work other than blasting and any work immediately incidental thereto and clearing and repairing of the enclosure including the plant and appliances situated therein, shall be performed in a blasting enclosure. Every door, aperture and joint of blasting enclosure, shall be kept closed and air-tight while blasting is being done therein.

   (b) Blasting enclosure shall always be maintained in good condition and effective measures shall be taken to prevent dust escaping from such enclosure, and from apparatus connected therewith, into the air of any room.

   (c) There shall be provided and maintained for and in connection with every blasting enclosure, efficient apparatus for separating, so far as practicable, abrasive which has been used for blasting and which is to be used again as an abrasive, from dust or particles of other materials arising from blasting; and no such abrasive shall be introduced into any blasting apparatus and used for blasting until it has been so separated:

Provided that this clause shall not apply, except in the case of blasting chambers, to blasting enclosures constructed or installed before the coming into force of this schedule, if the Competent Authority is of opinion that it is not reasonably practicable to provide such separating apparatus.

(d) There shall be provided and maintained in connection with every blasting enclosure efficient ventilating plant to extract, by exhaust draught effected by mechanical means, dust produced in the enclosure. The dust extracted and removed shall be disposed of by such method and in such manner that it shall not escape into the air of any room; and every other filtering or settling device situated in a room in which persons are employed, other than persons attending to such bag or other filtering or settling device, shall be completely separated from the general air of that room in an enclosure ventilated to the open air.

(e) The ventilating plant provided for the purpose of sub-paragraph (d) shall be kept in continuous operation whenever the blasting enclosure is in use whether or not blasting is actually taking place therein, and in the case of a blasting chamber, it shall be in operation even when any person is inside the chamber for the purpose of cleaning.

4. Inspection and examination.-

(a) Every blasting enclosure shall be specially inspected by a competent person at least once in every week in which it is used for blasting enclosure, the apparatus connected therewith and the ventilating plant shall be thoroughly examined and in the case of ventilating plant, tested by a competent person at least once in every month.

(b) Particulars of the result of every such inspection, examination or test shall forthwith be entered in a register which shall be kept in Form 10 and shall be available for inspection by any workman employed in or in connection with blasting in the factory. Any defect found on any such inspection, examination or test this paragraph applies shall be deemed for the purposes of this Paragraph to have been constructed, reconstructed or converted for use as such after the making of this Schedule if the construction, reconstruction or conversion thereof was begun after the making of this Schedule.

5. Provision of protective helmets, gauntlets and overalls.-

(a) There shall be provided and maintained for the use of all persons who are employed in a blasting chamber, whether in blasting or in any work connected therewith or in cleaning such a chamber, protective helmets of a type approved by a certificate of the Competent Authority; and every such person shall wear the helmet provided for this use whilst he is in the chamber and shall not remove it until he is outside the chamber.

(b) Each protective helmet shall carry a distinguishing mark indicating the person by whom it is intended to be used and no person shall be allowed or required to wear a helmet not carrying his mark or a helmet which has been worn by another person and has not since been thoroughly disinfected.

(c) Each protective helmet when in use shall be supplied with clean and not unreasonably cold air at a rate of not less than 170 litres per minute.

(d) Suitable gauntlets and overalls shall be provided for the use of all persons while performing blasting or assisting at blasting, and every such person shall while so engaged, wear the gauntlet and overall provided.

6. Precautions in connection with cleaning and other work -

(a) Where any person is engaged upon cleaning of any blasting apparatus or blasting enclosure or of any apparatus or ventilating plant connected therewith or the surroundings thereof or upon any other work in connection with any blasting apparatus or blasting enclosure or with any apparatus or ventilating plant connected therewith so that he is exposed to the risk of inhaling dust which has arisen from blasting, all practicable measures shall be taken to prevent such inhalation.

(b) In connection with any cleaning operation referred to in paragraph 5, and with the removal of dust from filtering or settling devices all practicable measures shall be taken to dispose of the dust in such a manner that it does not enter the air of any room. Vacuum cleaners shall be provided and used wherever practicable for such cleaning operations.

7. Storage accommodation for protective wear.- Adequate and suitable storage accommodation for the helmets, gauntlets and overalls required to be provided by paragraph 5 shall be proved outside and conveniently near to every blasting enclosure and such accommodation shall be kept clean. Helmets and overalls when not in actual use shall be kept in this accommodation.

8. Maintenance and cleaning of protective wear.- All helmets, gauntlets, overalls and other protective devices or clothings provided and worn for the purposes of this schedule, shall be kept in good condition and so far as is reasonably practicable shall be cleaned on every weekday in which they are used. Where dust arising from the cleaning of such protective clothing or devices is likely to be inhaled, all practicable measures shall be taken to prevent such inhalation. Vacuum cleaners shall, wherever practicable, be used for removing dust from such clothing and compressed air shall not be used for removing dust from any clothing.

9. Maintenance of vacuum cleaning plant.- Vacuum cleaning plant used for the purpose of this schedule shall be properly maintained.

10. Medical facilities and records of examinations and tests.-

(a) The occupier of every factory to which the Schedule applies, shall

(i) employ a qualified medical practitioner for medical surveillance of the workers employed therein, and whose

employment shall be subject to the approval of the Competent Authority; and

(ii) provide to the said medical practitioner all the necessary facilities for the purpose referred to in clause (i) above.

(b) The record of medical examinations and appropriate tests carried out by the said medical practitioner shall be maintained in a separate register approved by the Competent Authority which shall be kept readily available for inspection by the Inspector.

11. Medical examination by Certifying Surgeon.-

(a) Every worker employed in any of the processes to which this schedule applies shall be examined by a Certifying Surgeon within 15 days of his first employment. Such examination shall include pulmonary function test and chest X-ray. No worker shall be allowed to work after 15 days of his first employment in the factory unless certified fit for such employment by the Certifying Surgeon.

(b) Every worker employed in the said processes shall be re-examined by a Certifying Surgeon at least once in every 12 calendar months and such re-examination shall, wherever the Certifying Surgeon considers appropriate, include pulmonary function test and chest X-ray once in every three years.

(c) The Certifying Surgeon after examining a worker, shall issue a Certificate of Fitness in Form 1 .The record of examination and re-examinations carried out shall be entered in the Certificate and the Certificate shall be kept in the custody of the manager of the factory. The record of each examination carried under sub-paragraphs (a) and (b), including the nature and the results of the tests, shall also be entered by the Certifying Surgeon in a health register in Form 1A.

(d) The Certificate of Fitness and the health register shall be kept readily available for inspection by the Competent Authority.

(e) If at any time the Certifying Surgeon is of the opinion that a worker is no longer fit for employment in the said processes on the ground that continuance therein would involve special danger to the health of the worker, he shall make a record of his findings in the said certificate and the health register. The entry of his findings in those documents shall also include the period for which he considers that the said person is unfit for work in the said processes. The person so suspended from the process shall be provided with alternate placement facilities unless he is fully incapacitated in the opinion of the Certifying Surgeon, in which case the person affected shall be suitably rehabilitated.

(f) No person who has been found unfit to work in the said processes as said in sub-paragraph (e) above shall be reemployed or permitted to work unless the Certifying Surgeon, after further examination, again certifies him fit for employment in those processes.

Rule 88(Sch. X)

12. Power to exempt or relax.-

(a) If the Competent Authority is satisfied that in any factory or any class of factories, the use of sand or other substance containing free silica as an abrasive in blasting is necessary for a particular manufacture or process (other than the process incidental or supplemental to making of metal castings) and that the manufacture or process cannot be carried on without the use of such abrasive or that owing to the special conditions or special method of work or otherwise any requirement of this schedule can be suspended either temporarily or permanently, or can be relaxed without endangering the health of the persons employed or that application of any of such requirements is for any reason impracticable or inappropriate, it may, with the previous sanction of the Central Government, by an order in writing exempt the said factory or class of factories from such provisions of this schedule, to such an extent and subject to such conditions and for such period as may be specified in the said order.

(b) Where an exemption has been granted under sub-paragraph (a), a copy of the order shall be displayed at a notice board at a prominent place at the main entrance or entrances to the factory and also at the place where the blasting is carried on.

89. NOTIFICATION OF ACCIDENTS.-

(1) Where any accident specified in sub-para (a) of para 1 of the Schedule to this rule or any occurrences specified in para 2 of the said schedule takes place in a factory, the Manager of the factory, in which the accident occurred, shall within four hours of the happening of such accident or occurrence, send notice there of in Form 11 by telephone, telex, telegram or special messenger to the inspector and the Competent Authority and when the accident is fatal or it is of such a nature that it is likely to prove fatal, notice as aforesaid shall also be sent to-

(a) the District Magistrate or sub Divisional Magistrate;

(b) the Officer In Charge of the nearest Police Station;

(c) the Electrical Inspector (In case of electrical accident); and

(d) the relatives of the injured or deceased person.

(2) The notice so given shall be confirmed by the Manager of the factory to the above mentioned authorities within 12 hours of the accident/occurrence by sending a written report in Form 12 and in case of electrical accidents in Form 13 to the Electrical Inspector.

(3) When any accident of a minor nature specified in sub-para (b) of the said para 1 of the schedule takes place in a factory, the Manager of the factory shall within 24 hours after the expiry of the period specified in the said sub-para (b) , send notice thereof in the Form 11 to the medical officer; & the Competent Authority.

Rule 89

(4) If, in case of an accident, the injured person subsequently dies due to such accident, information of his death whenever known shall be sent by the Manager of the factory by telephone, telex, telegram or special messenger within 24 hours of the occurrence to-

(a) the District Magistrate or Sub-Divisional Magistrate;

(b) the Officer In Charge of the nearest Police Station;

(c) the Competent Authority; and

(d) the Electrical Inspector (In case of Electrical accidents).

EXPLANATION: Accident of serious nature means an accident which results in either or all of the following, namely:-

(i) Immediate loss of any part of the body or any limb or part there of;

(ii) Crushed or Serious injury to any part of the body due to which loss of the same is obvious or any injury which is likely to prove fatal;

(iii) Unconsciousness;

(iv) Severe burns or scalds due to chemicals, steam or any other cause; and

(v) Any injury to man/animal due to electrical energy.

(5) The Manager of the factory shall lay down the procedures for investigation of all accidents and occupational illnesses reported as per Forms 12 and 14.

SCHEDULE

1. (a) Accidents which cause death to any person or are of a serious nature.

(b) Accidents which cause such bodily injury as prevents or will probably prevent the person injured from working for a period of 48 hours or more immediately following the accident.

2. The following classes of occurrences, whether or not they are attended by personal injury or disablement:-

(a) Bursting of a vessel used for containing steam under pressure greater than atmospheric pressure, other than plant which comes within the scope of the Indian Boilers Act.

(b) Collapse or failure of a crane, derrick, winch, hoist or other appliances used in raising or lowering persons or goods or any part thereof, or the overturning of a crane.

(c) Explosion, fire, bursting out, leakage or escape of any molten metal, or hot liquor or gas causing bodily injury to any person or damage to any room or place in which persons are employed.

(d) Explosion of a receiver or container used for the storage at a pressure greater than atmospheric pressure of any gas or gases(including air) or a liquid or solid resulting from the compression of gas.

(e) Collapse or subsidence of any floor, gallery, roof, bridge, tunnel, chimney, wall or building, forming part of a factory or within the compound or curtilage of factory.

3. Leakage or release of effluents to the outside environment above those specified by the Department of Environment and Air and Water Pollution Control Boards.

90. NOTICE OF POISONING OR DISEASE. - A notice in Form 14 shall be sent with in four hours to the Competent Authority by the manager of the factory in which there occurs a case of poisoning or disease due to items mentioned in the Third Schedule of section 45 of the Factories Act, 1948(63 of 1948).

98. REGISTER OF ACCIDENTS AND DANGEROUS OCCURRENCES. - The manager of every factory shall maintain a register of all accidents and dangerous occurrences which occur in the factory. All these shall be investigated thoroughly and causes established. Any deficiency found in respect of systems & practices shall be corrected & report thereof shall be made available to the inspector & Competent Authority.

99. MAINTENANCE OF INSPECTION BOOK.- The manager of every factory shall maintain a register of inspection reports and shall produce it when so required by the Competent Authority or Certifying Surgeon.

101. COMMUNICATION FACILITIES.- The Manager shall establish effective communication facilities so that in the normal as well as in emergency conditions the Shift-in-charge is able to contact without delay the factory manager, control room, security, fire station, dispensary, workers and the outside agencies such as police, fire brigade, hospital, district magistrate, civil defence post.

102. SPECIAL POWERS OF THE COMPETENT AUTHORITY.- The Competent Authority shall have powers to notify specific safety procedures, guides, manuals to enhance safety & health in any factory.

Form - 1

CERTIFICATE OF FITNESS TO WORK ON SPECIFIED JOB

(See rules 7(3), 32 Sch. III, 33, 55, 88)

1. Name of the Factory:

2. Name of the Person

   (In Block letters) and Employee No.

   Sex: M/F Date of birth:

3. Educational Qualifications:

4. Previous Experience :

   Field of Experience :

5. Details of Medical Examination : Date

   .1. Height..... .cm. .2. Weight..... ...kg.

   .3. Hearing (Auditory Examination): Normal/Not normal*

   .4. Eyesight : Normal/Normal with spects/Not normal*

   : Colour blindness : Yes/No

   .5. General Laboratory Investigations (Blood, urine, excreta, sputum etc.): Normal/Not normal*

   .6. Pulmonary function & Chest Examination : Normal/Not normal*

   (including X ray examination)

   .7. Nervous system: Normal/Not normal*

   .8. Overall health assessment:

* Specify the condition & remedial measures.

(2)

6. I certify that I have personally examined Dr./Shri/Smt./Kum.. …..... . and seen his/her other medical reports and my recommendations are recorded below.

7.	Work with/in/at	Recommendations
.1.	Chemicals and hazardous materials including prescribed materials	Fit/Unfit
.2.	Machines	
	.2.1 Cranes	Fit/Unfit
	.2.2 Locomotives	Fit/Unfit
	.2.3 Fork lifts	Fit/Unfit
.3.	Blasting by compressed air/steam for cleaning of articles.	Fit/Unfit
.4.	Radioactive Area	Fit/Unfit
.5.	Any other work specified by the Competent Authority...	Fit/Unfit

Signature of Certifying Surgeon

Name ……...

Date: Reg.No. ..

Note: Strike out whichever is not applicable.

Medical Examination Record

S.No.	**Date of**		**Remarks**
-----	**----------**		**----------**
	Last Examination	**Next Examination**	

Form - 1A

HEALTH REGISTER OF WORKERS EMPLOYED ON SPECIFIED JOBS

(See rules 7(4), 88)

Name of the Factory:

S.No.	Name	Age Yrs.	Nature of job	Date of			If suspended from work period of suspension	Date of resumption of duty	Signature with date of certifying surgeon
				Medical Exam.	Employment in present work	Learning or transfer to other work			

N.B. Against column Nature of job please write the applicable number as given below:

(1) Working with Chemicals & Hazardous materials.

(2) Working with-2.1 rotating machines; 2.2 lifting machines; 2.3 material handling equipment.

(3) Working with -3.1 electrical work-low & medium voltage; 3.2 electrical work-high voltage.

(4) At height.

(5) At blasting by compressed air/steam for cleaning of articles.

(6) Radioactive area.

Form - 3

REPORT OF EXAMINATION OF HOISTS & LIFTS

(See Rule 34)

1. Name of the Factory :

2.1 Type of hoist or lift and identification No. or description :

2.2 Date of construction/reconstruction :

3. Are all parts of the hoist or lift, of good mechanical construction, sound material and adequate strength (so far as ascertainable) :

4. Are the following parts of the hoist or lift properly maintained and in good working order? If not, state what defects have been found. :

.1. Enclosure of hoistway or liftway :

.2. Landing gates and cage gate(s) :

.3. Interlocks and the landing gates and cage gate(s) :

.4. Other gate fastenings :

.5. Cage and platform and fittings, guides, buffers, interior of the hoistway or liftway. :

.6. Overrunning devices :

.7. Suspension ropes or chain and their attachments. :

.8. Safety gear i.e. arrangement for preventing fall of platform or cage brakes. :

.9. Brakes :

.10. Worm or spur gearing :

.11. Other electrical equipment :

.12. Other parts :

5. What parts(if any) were inaccessible :

6. Repairs, renewals :

7. Maximum safe work load :

(2)

8. Is any of the lift made as per requirements of fire lift & if so its location & identification No. :

9. Other particulars :

I/we certify that on (date) ... . I/we thoroughly examined this hoist or lift and that the above is a correct report of the result.

Signature:

Date: **Name :**

Form - 4

REPORT OF EXAMINATION OF LIFTING MACHINES

Ropes & Lifting Tackles

(See rule 35(4))

1.	Name of the Factory	:
2.	Distinguishing number or mark (if any) and description sufficient to identify the lifting machine, chains, rope or lifting tackle.	:
3.	Date when lifting machine chain, rope or lifting tackle was first used in the factory.	:
4.	Date and number of certificate of last examination made under section 29(1)a (iii) and by whom it was carried out.	:
5.	Date and number of certificate relating to any test & examination made, under rules 35.1 & 35.15 together with the name & address of the certifying person.	:
6.	Date & certificate of annealing or other heat treatment of the chain and lifting tackle carried out as per rule 35.7 and by whom it was carried out.	:
7.	Particulars of any defect found at any such examination or after annealing and affecting the safe working load and steps taken to remedy such defect.	:

I/We certify that on .....……..... I/We thoroughly examined the above mentioned lifting machine/chain rope/lifting tackle and that the above is a correct report of the result.

Signature:

Date: **Name:**

Form - 7

ITEM FIELD PERFORMANCE REPORT

(See rule 60)

1.	Name of the Factory		:
2.	Item		:
	.1	Identification	:
	.2	Manufacturer	:
	.3	Number of items of the type	:
	.4	Date of manufacture	:
	.5	Date of modification/reconditioning	:
	.6	Date first placed in use	:
	.7	Cumulative operating time since above	:
	.8	Date & place where used after 2.5	:
	.9	Date/ cumulative operating time since above	:
	.10	Cumulative time-Non use (Storage/Maintenance)	:
4.	Operating environment		:
	.1	Temperature Range	:
	.2	Relative humidity range	:
	.3	Nature of atmosphere A.C./Clean/Dusty/Corrosive/...	:
	.4	Vibration level	:
5.	Mode of operation Continuous/Intermittent/Standby/...		:

6.	Item failure information		:
	.1	Symptoms of failure	:
	.2	Failure detected during Operation / Periodic check / Preventive maintenance	:
	.3	Functions affected by failure	:
	.4	Failure cause	:
		Inherent/Misuse/ Maintenance induced/	:
		External to item/ Secondary/Unknown	:
7.	Item failure analysis and correction		:
	.1	List of failed parts	:
	.2	List of replaced parts	:
	.3	Adjustments made	:
8.	Total active downtime		:
9.	Total downtime		:
10.	Any other information		:

Signature:

Date:

Name :

Designation:

Form - 8

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

[F M E C A]

(See rule 60)

Name of the Factory:

System : ...

Sub System: ... Page _____of _____

Code No. : ...

No.	Part No.	Part		Failure Mode		Detection Method	Effect on System Plant	Remarks
		Name	Function	No.	Description			
1	2	3		4		5	6	7

Prepared By ... Checked By ... Approved By ...

Form - 11

PRELIMINARY REPORT OF ACCIDENT OR DANGEROUS OCCURRENCES

(See rules 89(1), 89(3))

1.	Name of the Factory	:	
2.	Name of injured person & address	:	
	Official	:	
	Residential	:	
3.	a) Sex : M/F	b)	Age:
	c) Designation :	d)	Pay:
4.	Date and hours of accident/dangerous occurrence	:	
5.	Cause & Nature of accident/dangerous occurrence	:	

Date: **Manager** **Signature:**

Place: **Name :**

1. District/Sub Divisional Magistrate
2. Officer in charge of nearest police station
3. Inspector concerned.
4. Competent Authority.
5. Relatives of the injured/deceased.
6. Electrical Inspector.[In case of Electrical Accidents.]

In case of fatal accident or if it is of such a nature that it is likely to be

Form -12

NOTICE OF ACCIDENTS OR DANGEROUS OCCURRENCE

(See rules 89(2), 89(5))

1. Name of the Factory :

2. Branch or section & exact place where the accident or dangerous occurrence happened :

3. Name of injured person :

   Address Official :

   Residential :

4. a) Sex : M/F b) Age :

   c) Designation : d) Pay :

5. Date and hour of accident or dangerous occurrence :

6. Hours at which he started work on the day of accident :

7. a) Cause & nature of accident or dangerous occurrence :

   b) If caused by machinery :

      i) Name of the machine and part causing the accident, & :

      ii) Whether it was moved by mechanical power at that time : Yes/No

   c) Exactly what injured person was doing at that time :

8. Names & addresses of the witnesses to the accident : 1)

   : 2)

9. Nature & extent of Injury :

10. Period of disability :

11.	If accident is not fatal, state whether injured person is likely to be disabled for 48 hours or more	:	Yes/No
12.	Name of Medical Officer in attendance on injured person	:	

I certify that to the best of my knowledge and belief that the above particulars are correct in every respect.

Date: **Manager** **Signature :**

Place: **Name :**

Competent Authority.

Form - 13

FORM FOR REPORTING ELECTRICAL ACCIDENTS

(See rule 44-A of the Indian Electricity Rules,1956;

&

Atomic Energy (Factories)Rules, 1996; rule 89(2))

1.	Date and time of accident	:
2.	Place of accident and district	:
3.	System & Voltage of supply	:
4.	Name of the licensee or person/persons or supplier or user of energy in whose premises or jurisdiction the accident occurred	:
5.	a) (i) Name of the person	:
	(ii) Animal(please specify the name and address of the owner)	:
	b) Address of such/each person	:
6.	Occupation and designation of such person/persons (and in particular whether employed in electrical works or elsewhere)	:
7.	Brief description of the job undertaken, if any	:
8.	Authority under which such person / persons was / were allowed to work on the job. State also whether he/they was/were authorised person/persons	:
9.	Describe fully nature and extent of injuries, e.g. fatal, disablement of any portion of body or other injury, etc.	:
10.	Detailed causes leading to the accident	:
11.	Action taken regarding first aid, medical attendance, etc. immediately after the occurrence of the accident.	:
12.	Whether appropriate Govt. Dist. and police station informed (if so, give the address).	:

(2)

13.	Steps taken to preserve the evidence in connection with the accident to the extent possible.	:
14.	Name and designation/s of the person/s assisting the person/s killed or injured.	:
15.	What safety equipment were given to and used by the person/s who met with this accident(e.g. rubber gloves, rubber mats, safety belts and ladders, etc.).	:
16.	Whether isolating switches and other sectionalising devices were employed to deaden the sections for working on the same, if so, whether these were earthed.	:
17.	Whether the work on live lines was undertaken by an authorized person/s. If so, the name and designation of such person/s may be given.	:
18.	Whether artificial resuscitation treatment was given to the person who met with electric accident. If yes, for how long was it continued, before abandonment.	:
19.	Steps proposed to be taken to avoid recurrence	:
20.	Names and designations of persons present at the time of accident.	:
21.	Any other remarks	:

Date: **Manager** **Signature :**

Time: **Name:**

1. Electrical Inspector of the region.

2. Competent Authority.

Form - 14

Notice of Poisoning or Disease

(See rules 89(5), 90)

1.	Name of the Factory		:	
2.	Name and address of the undertaking in which the patient presumes that he was exposed to the risk to which the poisoning or disease is attributed.		:	
3.	Harmful agent or process		:	
4.	Patient.	Name	:	
		Address	:	
5.	1. Sex : M/F		2.	Age :
	3. Designation:		4.	Pay :
6.	Precise occupation of the patient		:	
	.1	at the place or last place of employment	:	
	.2	at the undertaking in which the patient presumes that he was exposed to the risk.	:	
7.	Nature of poisoning or disease.		:	
8.	Approximate dates of beginning & cessation of exposure of the patient to the harmful agent or process mentioned in 3 above.		:	
9.	General particulars		:	

Manager, **Signature:**

Date: **Name:**

Competent Authority.

MODEL RULES FOR LABOUR WELFARE

MODEL RULES FOR LABOUR WELFARE

1. **Definitions:**

(a) "Work Place" means a place at which, on an average, twenty or more workers are employed.
(b) "Large work place" means a place at which, on an average 500 or more workers are employed.

2. **First Aid** :

At every workplace, there shall be maintained in a readily accessible place first aid appliances including an adequate supply of sterilized dressings and sterilized cotton wool as prescribed in the Factory Rules of the State in which the work is carried on. The appliances shall be kept in good order and in large work-places, they shall be placed under the charge of a responsible person who shall be readily available during working hours.

At large workplaces, where hospital facilities are not available within easy distance of the works First Aid Posts shall be established and be run by trained compounders.

Where large workplaces are remotely situated and far away from regular hospitals, an indoor ward shall be provided with one bed for every 260 employees.

Where large workplaces are situated in cities, towns or in their suburbs and no beds are considered necessary owing to proximity of city or town hospitals, suitable transport shall be provided to facilitate removal of urgent cases to these hospitals. At other workplaces, some conveyance facilities shall be kept readily available to take injured person or person suddenly taken seriously ill, to the nearest hospital.

At large workplaces these shall be provided and maintained an ambulance room of the prescribed sizes, containing the prescribed equipment and in the charge of such medical and nursing staff as may be prescribed. For the purpose the relevant provisions of the Factory Rules of the State Government of the area where the work is carried on may be taken as the prescribed standard.

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3. **Accommodation for Labour** :

The Contractor shall during the progress of the works provide, erect and maintain necessary temporary living accommodation and ancillary facilities for labour at his own expense and to standards and scales as approved by the Engineer-in-Charge.

4. **Drinking water** :

In every workplace, there shall be provided and maintained at suitable places easily accessible to labour, a sufficient supply of cold water fit for drinking.

Where drinking water is obtained from an intermittent public water supply each workplace shall be provided with storage where drinking water shall be stored.

Every water supply storage shall be at a distance of not less than 15 meters from any latrine drain or other source of pollution. Where water has to be drawn from an existing well, which is within such proximity of latrine, drain or any other source of pollution, the well shall be properly chlorinated before water is drawn from it for drinking. All such wells shall be entirely closed in and be provided with a trap door which shall be dust and water-proof.

A reliable pump shall be fitted to each covered well, the trap door shall be kept locked and opened only for cleaning or inspection which shall be done at least once a month.

5. **Washing and Bathing Places** :

Adequate washing and bathing places shall be provided separately for man women. Such places shall be kept in clean and drained condition.

6. **Scale of Accommodation in Latrines and Urinals** :

There shall be provided within the precincts of every workplace latrines and urinals in an accessible place, and the accommodation, separately for each of these, shall not be less than at the following scales:-

	No. of Seats
(a) Where number of persons does not exceed 50	2
(b) Where number of persons exceeds 50 but does not exceed 100	3

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(c) For additional persons per 100 or part thereof 3

In particular cases, the Engineer-in-Charge shall have the power to increase the requirement, where necessary.

7. **Latrines and Urinals** :

Except in workplaces provided with water flushed latrines connected with a water-borne sewage system. All latrines shall be provided with receptacles or dry-earth system which shall be cleaned at least four times daily and at least twice during working hours and kept in a strictly sanitary condition. Receptacles shall be tarred inside and outside at least once a year. If women are employed, separate latrine and urinals screened from those for men and marked in the vernacular in conspicuous letters "For Women Only" shall be provided on the scale laid down in rule 6. Those for men shall be similarly marked "For Men Only". A poster showing the figure of a man and of a woman shall also be exhibited at the entrance to latrines for each sex. There shall be adequate supply of water close to latrines and urinals.

8. **Construction of Latrines**:

Inside walls shall be constructed of masonry or some suitable heat resisting nonabsorbent materials and shall be cement washed inside and outside at least once a year. The dates of cement washing shall be noted in a register maintained for the purpose and kept available for inspection. Latrines shall have at least thatched roof.

9. **Disposal of Excreta** :

Unless otherwise arranged for by the local-sanitary authority, arrangements for proper disposal of excreta by incineration at the workplace shall be made by means of a suitable incinerator approved by the local medical health and municipal or cantonment authorities. Alternatively excreta may be disposed off by putting a layer of night soils at the Bottom of pucca tank prepared for the purpose and covering it with a 15 cm layer of waste or refuse and then covering it with a layer of earth for a fortnight(when it will turn into manure).

The Contractor shall, at his own expense, carry out all instructions issued to him by the Engineer-in-charge to effect proper disposal of soil and other conservancy work in respect of Contractor`s work people or employees on the Site. The Contractor shall be responsible for payment of any charges

which may be levied by municipal or cantonment authority for execution of such work on his behalf.

10. **Provision of shelters during rest** :

At every work place there shall be provided free of cost, four suitable sheds, two for meals and two others for rest, separately for use of men and women Labour. Height of each shelter shall not be less than 3 meters from floor level to lowest part of roof. Sheds shall be kept clean and the space provided shall be on the basis of at least 0.5 sq.m. per head.

11. **Crèches** :

At a place at which 20 or more women workers are ordinarily employed, there shall be provided at least one hut for use of children under the age of 6 years belonging to such women, Huts shall not be constructed to a standard lower than that of thatched roof, mud floor and wall with wooden plants spread over mud floor and covered with matting.

Huts shall provided with suitable and sufficient openings for light and ventilation. There shall be adequate provision of sweepers to keep the places clean. There shall be two dais in attendance. Sanitary utensils shall be provided to the satisfaction of local medical health and municipal or cantonment authorities. Use of huts shall be restricted to children their attendance and mothers of children.

Where the number of women workers is more than 25 but less than 50, the Contractor shall provide at least one hut and one dai to look after children of women workers.

Size of creche (s) shall vary according to the number of women workers employed.

Creche (s) shall be properly maintained and necessary equipment like toys etc., provided.

12. **Canteen** :

A cooked food canteen on a moderate scale shall be provided for the benefit of workers wherever it is considered necessary.



13. **Planning** :

Setting and erection of the above mentioned structures shall be approved by the Engineer-in-Charge, and the whole of such temporary accommodation shall at all times during the progress of the works be kept tidy and in a clean and sanitary condition to the satisfaction of the Engineer-in-Charge and at the Contractor`s expenses. The Contractor shall conform generally to sanitary requirements of local medical, health and municipal or cantonment authorities and at all times adopt such precautions as may be necessary to prevent soil pollution of the Site.

On completion of the Works the whole of such temporary structures shall be cleared away, all rubbish burnt, excreta or other disposal pits or trenches filled in and effectively sealed off and the whole of site left clean and tidy to the entire satisfaction of the Engineer-in-Charge and at the Contractor`s expenses.

14. **Anti-malarial precautions** :

The Contractor shall, at his own expense, conform to all anti-malarial instructions given to him by the Engineer-in-Charge, including filling up any borrow pits which may have been dug by him.

15. **Enforcement** :

The Inspecting Officer mentioned in the Contractors Labour Regulations or any other officer nominated in his behalf by the Engineer-in-Charge shall report to the Engineer-in-Charge all cases of failure on the part of the Contractor and or his subcontractors to comply with the provisions of these Rules either wholly or in part and the Engineer-in-Charge shall impose such fines and other penalties as are prescribed in the conditions.

16. **Interpretations etc**. :
On any question as to the application, interpretation or effect of these Rules, the decision of the Chief Labour Commissioner or Deputy Chief Labour Commissioner(Central) shall be final and binding.

17. **Amendments** :

Government may, from time to time add to or amend these Rules and issue such directions as it may consider necessary for the proper implementation of these Rules or for the purpose of removing any difficulty which may arise in the administration thereof.

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GUIDELINES NO. AERB/NRF/SG/IS-1 (Rev. 1)

GUIDELINES NO. AERB/NRF/SG/IS-1 (Rev. 1)



GOVERNMENT OF INDIA

AERB SAFETY GUIDELINES

CONTROL OF WORKS



ATOMIC ENERGY REGULATORY BOARD

AERB SAFETY GUIDELINES NO. AERB/NRF/SG/IS-1 (Rev. 1)

CONTROL OF WORKS

Atomic Energy Regulatory Board
Mumbai-400 094
India

December 2011

Price

Order for this guidelines should be addressed to:

The Administrative Officer
Atomic Energy Regulatory Board
Niyamak Bhavan
Anushaktinagar
Mumbai-400 094
India

FOREWORD

Activities concerning establishment and utilisation of nuclear facilities and use of radioactive sources are to be carried out in India in accordance with the provisions of the Atomic Energy Act, 1962. In pursuance of the objective of ensuring safety of members of the public and occupational workers as well as protection of environment, the Atomic Energy Regulatory Board (AERB) has been entrusted with the responsibility of laying down safety standards and enforcing rules and regulations for such activities. The Board, therefore, has undertaken a programme of developing safety standards, safety codes and related guides and manuals for the purpose. While some of the documents cover aspects such as siting, design, construction, operation, quality assurance and decommissioning of nuclear and radiation facilities, other documents cover regulatory aspects of these facilities.

Safety codes and safety standards are formulated on the basis of nationally and internationally accepted safety criteria for design, construction and operation of specific equipment, structures, systems and components of nuclear and radiation facilities. Safety codes establish the objectives and set requirements that shall be fulfilled to provide adequate assurance for safety. Safety guides and guidelines elaborate various requirements and furnish approaches for their implementation. Safety manuals deal with specific topics and contain detailed scientific and technical information on the subject. These documents are prepared by experts in the relevant fields and are extensively reviewed by advisory committees of the Board before they are published. The documents are revised when necessary, in the light of experience and feedback from users as well as new developments in the field.

Construction work is a labor-intensive industrial activity with large number of unskilled and migratory workforce under various contracts ranging from a mega package contract to a small work contract. Accidents during construction work are of major concern because of the high severity of injuries. The analysis of the accidents at construction sites indicates that 'fall from height' type of accidents are significantly higher than the other types of accidents. AERB safety guide titled 'Works Contract' (AERB/SG/IS-1) was issued in 1991 to emphasise safety requirements and ensure their implementation in execution of contracts. In view of the continual development of construction technologies and the need for enhancement of indutrial safety in DAE units, inputs from AERB discussion meets on the subject, safety and occupational health professionals of DAE, AERB Fatal accident Assessment Committee, and directives on industrial safety issued by Chairman, AERB, the need for revision of the safety guide was felt.

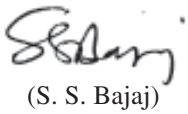
This revised 'safety guidelines' is effective from the date of issue and supersedes the earlier guide on the subject. Part-A of the revised safety guidelines highlights safety requirements by 'Facilities' and Part-B highlights the requirements on safe execution of jobs by 'Contractors'. The facility management shall be strictly liable as a principal

employer for ensuring the compliance with the safety requirements by the contractors as laid down in Part-B. It should be noted that Part-A and Part-B should be read in conjunction, as the requirements are complementary to each other. However the 'Facility' may issue the Part-B along with the tender documents. The requirements spelt out in this 'safety guidelines' are in addition to the statutory requirements such as Factories Act 1948, Atomic Energy (Factories) Rules, 1996 and other applicable statutory requirements.

Consistent with the accepted practice, 'shall' and 'should' are generally used to distinguish between a firm requirement and a desirable option respectively. Appendices are an integral part of the document, whereas bibliography are included to provide further information on the subject that might be helpful to the user.

Specialists in the field drawn from the Atomic Energy Regulatory Board, the Bhabha Atomic Research Centre and the Nuclear Power Corporation of India Limited and other consultants have prepared this 'safety guidelines' document. It has been reviewed by the Advisory Committee on Industrial and Fire Safety (ACIFS).

AERB wishes to thank all individuals and organisations who have prepared and reviewed the document and helped in its finalisation. The list of persons, who have participated in this task, along with their affiliations, is included for information.



(S. S. Bajaj)
Chairman, AERB

SPECIAL DEFINITIONS
(Specific for the Present 'Guidelines')

Approval

A type of written consent issued by the designated authority.

Construction Agency/Contractor

An individual or organisation rendering services of design/construction/fabrication/ installation/repair/inspection/review/maintenance/supplying items by the deployment of workers at site.

Dangerous Manufacturing Processes or Operations

The manufacturing processes or operations as specified under Rule 88 of the Atomic Energy (Factories) Rules, 1996.

Engineer-in-charge

A person designated by the Facility to act as an overall in-charge of work.

Facility

Any Unit of the Department of Atomic Energy awarding the contract.

Head, Industrial Safety

The chief safety officer or the overall in charge of Industrial Safety Section of the facility.

Line Managers

The person who has the field level managerial and supervisory control on the concerned work.

Safety Related Deficiency

The unsafe acts/unsafe practices/unsafe conditions in the work area, which have potential to cause injury/accident resulting into undesirable consequences to human beings or damage to the equipment/property/environment.

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PART-A

CONTROL OF WORKS
(FACILITIES)

1. INTRODUCTION

1.1 General

Department of Atomic Energy (DAE) through its constituent units execute various site works either by their own manpower or by manpower of various outside agencies. The nature of contracts with outside agencies can be works contracts, engineering procurement contracts, minor fabrication contracts etc. These site works involve entire gamut of conventional industrial activities like excavation, rock blasting, earth handling, construction, material handling, fabrication, installation, operation, maintenance etc. of nuclear or conventional plants/facilities. This is a challenging responsibility for the facility due to the complexity of problems like quality of workforce (which may be unskilled, illiterate, migratory) available for labor-intensive jobs, lack of coordination among agencies at site, lack of safety awareness among concerned authorities, time schedules of project etc. As primary employer of the workforce (facility or contractor) at site, it is the responsibility of the facility management to ensure health and safety of personnel engaged for the work. Any accidental injury or loss of life is detrimental to the facility as well as the society. This 'guidelines' covers the safety organisation and the safety management system requirements in sections two and three. The work specific safety precautions are covered in section four. The requirements relating to personal protective equipment and medical management are covered in sections five and six.

1.2 Objective

This 'guidelines' has a basic framework of industrial safety organisation, safety management systems, safe work procedures to maintain a safe working environment for all personnel and to prevent any unsafe condition/act endangering the life of personnel engaged for industrial activities. The major objectives of this 'guidelines' are:

(i) To create awareness among workers about industrial hazards and safe working procedures.

(ii) To lay down safe work procedures and systems to be followed for different type of industrial activities

(iii) To establish a robust safety management system.

(iv) To protect the health and ensure the safety of the workers from industrial activities.

1.3 Scope

This 'guidelines' is essential for implementation and assurance of conventional safety in areas such as industrial, chemical, electrical, fire, environmental and is applicable for all works taken up by the facility as well as contracted works like engineering procurement contract, minor fabrication contract etc. Where the execution of work is envisaged in radiation controlled area or involves handling and fabrication of any nuclear material, additional precautions noted in relevant AERB safety documents on radiation protection shall also be applicable.

2. SAFETY ORGANISATION

2.1 General

(a) Construction projects have significant health and safety hazards, which need to be managed systematically since the project inception stage to achieve adverse incident free completion. A well-defined safety organisation helps in effective implementation of safety management systems and ensures health and safety of workers.

(b) The safety organisation should assure the management that all the provisions of relevant Acts and Rules are conformed to.

(c) Safety organisation should comply with all the requirements such as safety surveillance, safety training, safety enforcement measures, safety audit etc. related to all works to fulfill the overall safety requirements of this 'guidelines'.

(d) Safety functionaries should be exclusively assigned with the work related to protection of health and safety of workers.

(e) Safety organisation should directly report to the Project Director / Project Manager.

(f) IS: 18001: 2007 gives detailed requirements of health and safety management system requirements. IS: 15793 gives requirements of good practices for managing environment, occupational health and safety legal compliance. This 'guidelines' prescribes requirements in addition to IS: 18001: 2007 and IS: 15793 and gives guidelines on implementing these specific to a construction project.

(g) The requirements prescribed in various central and state regulations including *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996 and rules framed thereunder with respect to managing health and safety in construction projects, shall be complied with.

2.2 Organisational Structure for Safety Management

(a) Organisational structure depends on the construction project. As an example, a typical organisational chart for safety management in a construction project would be as given in Fig 1.

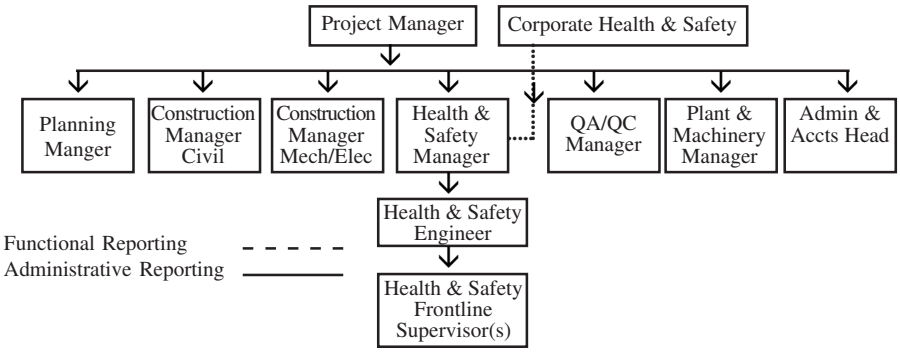


Fig -1 : Typical Organisation Chart

(b) The organisational structure for Health and Safety will vary from project to project. On large and medium projects, it may be necessary to have a separate safety team for each sub-contractor who in turn shall report to safety team of the main construction agency.

(c) The qualification, experience and the minimum number of safety professionals to be deployed should be as per the following table:

TABLE-1 : QUALIFICATION, EXPERIENCE & NUMBER OF SAFETY PROFESSIONALS FOR CONSTRUCTION PROJECTS

Category of safety person	Mandatory requirement	Qualification
Head, industrial safety	One at each site/unit	Degree in engineering/technology and diploma in industrial safety with minimum three years of experience
Safety officer	One in each shift (minimum) up to 1000 workers. If number of workers in a shift (including contractor's workers) exceeds 1000, additionally one safety officer should be deployed for every 1000 workers or part thereof.	Degree in engineering/technology and diploma in industrial safety with minimum two years of experience or Diploma in engineering with diploma in industrial safety with minimum 6 years experience or A recognised degree in physics or chemistry and has practical experience of working in a factory in a supervisory capacity for a period of not less than 5 years.

Category of safety person	Mandatory requirement	Qualification
	One in each shift (minimum) up	Not withstanding the provision contained in the above criteria any person who (i) possesses a recognised degree or diploma in engineering or technology and has had experience of not less than five years in a department of the central or state government which deals with the administration of the Factories Act, 1948 or the Dock Workers (safety, health and welfare) Act, 1986 (54 of 1986) or (ii) Possesses a recognised degree or diploma in engineering or technology and has had experience of not less than 5 years, fulltime on training, education, consultancy, or research in the field of accident prevention in industry or in any institution, shall also be eligible for appointment as a safety officer: Provided that competent authority may, subject to such condition as it may specify, grant exemption from the requirement of this sub rule if in its opinion, a suitable person possessing the necessary qualification and experience is not available for appointment.
Safety supervisor	to 500 workers. If number of persons working in a shift (including the contractors' workers) exceeds 500, additionally one safety supervisor should be deployed for every 500 workers or part thereof.	Diploma in engineering and diploma in industrial safety

3. SAFETY MANAGEMENT

3.1 General

(a) Pre-construction stage activities of the project shall be required to be reviewed before the project management processes are initiated for the construction stage. While the project documents and proposals are reviewed for the adequacy of health and safety measures, it is essential to ascertain timeframes and budgets relating to health and safety measures, including extent of management systems proposed to be employed during construction.

(b) A concise safety management system of the facility shall be established from the pre-construction stage itself. The tender documents of the project shall clearly communicate the health and safety requirements of the project to the prospective contractors. These may include:

(i) Project specific objectives and targets

(ii) Project specific health and safety requirements (technical as well as management systems)

(iii) Requirement of posting safety officers

(iv) Coordination among owner/client, project manager, consultants and facility

(v) Welfare facilities at the project for workmen

(vi) Reward system for good health and safety performance

(vii) Penalty system for non-compliances, violation and adverse incidents

(viii) Health and safety monitoring measures

(ix) Health and safety reports to be submitted and frequency.

(c) The construction agencies (contractors) should be asked to submit a project specific health and safety plan (construction safety management plan) proposing the methodology for managing health and safety and their capability in completing the project in a safe manner.

(d) The proposed construction safety management plans of the construction agencies and their past health and safety performance shall be considered as one of the criteria during pre-qualification and selection of construction agencies.

3.2 Safety Policy

(a) The facility and the construction agency jointly or separately shall have a written statement prescribing the health and safety policy of the organisation. The health and safety policy conveys the management commitment and intent of the organisation towards health and safety, its organisation and arrangements to ensure that the set objectives are met. It also provides a framework for establishing, maintaining and periodically reviewing health and safety objectives and targets.

(b) Health and safety policy shall meet the requirements of *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996 and IS 18001.

(c) The policy shall be communicated to all stakeholders through display and other means. The policy shall be displayed in local language(s) which may be understood by majority of the workmen.

3.3 Safety Plan

(a) A project specific health and safety plan shall be developed by the facility. On approval by the project director, the project health and safety plan shall be reference document for implementation, control and monitoring of health and safety aspects of the project by the facility.

(b) Project health and safety plan shall describe how the project specific health and safety objectives and targets shall be achieved. It shall define the road map for achieving the standards that an organisation lays down for itself so that efforts can be coordinated, synergised and monitored.

(c) Health and safety plan shall explain the means of establishing a positive health and safety culture at the project site. Health and safety plan shall identify and enumerate the control measures to mitigate the risks to the project completion arising out of health and safety issues so that the project is allowed to proceed without interruption and executed as per schedule.

Salient aspects that may be covered in the project health and safety plan are:

(i) Project specific health and safety objectives, targets and programmes in line with health and safety policy

(ii) Hazard identification and risk assessment

(iii) Meeting legal and other requirements

(iv) Health and safety organisation

(v) Resources, roles, responsibility and authority

(vi) General health and safety rules

(vii) Health and safety requirements to be followed by sub-contractors

(viii) Operation control procedure

(ix) Activities requiring work permit system and its procedure

(x) Safe handling of chemicals, explosives, gas cylinders, electrical equipment etc.

(xi) Access control of employees

(xii) Safety of visitors

(xiii) Management of critical activities such as work at height, material handling and working with plant and machinery

(xiv) Ensuring the competency and awareness of the workmen

(xv) Fire prevention and fire fighting plan

(xvi) Emergency preparedness and response plan

(xvii) Traffic management plan

(xviii) Training matrix

(xix) Personal protective equipment matrix

(xx) Health and safety performance monitoring measures such as inspection and audit

(xxi) Incident reporting and investigation procedure

(xxii) Proactive and reactive indicators of health and safety

(xxiii) Reward and reprimand for health and safety performance

(xxiv) Checklist and formats

(xxv) Health monitoring plan for employees/workers enposed to hazardus job.

(d) The risk control measures identified shall meet the provisions of *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996, other legislations and provisions of various safety related standards.

(e) Procedures shall be established for timely recording and reporting of information required for continual improvement of health and safety performance. Internal reporting procedures shall cover:

(i) Incident reporting

(ii) Non-conformance reporting

(iii) He alth and safety performance reporting

(iv) Hazard identification reporting

External reporting shall cover

(i) Statutory reporting requirements

The recording of reporting of health and safety performance shall be clearly documented in the project health and safety plan.

3.4 Roles, Responsibility and Authority

(a) Project manager shall define, document and communicate the roles, responsibilities and authorities of all personnel who manage, perform and verify activities having an effect on health and safety risks. It shall also include contractors and visitors.

(b) Ultimate responsibility for health and safety shall rest with top management of the respective organisation.

(c) The line management personnel who are responsible for execution of activities are directly responsible for health and safety in the work under their control.

(d) Health and safety group and health and safety officers are responsible for guiding the top management on health and safety issues and facilitating the implementation of health and safety in the project site. For duties and responsibilities of health and safety officers refer Atomic Energy (Factories) Rules-1996.

(e) Health and safety officers shall administratively report to the project manager and functionally report to the senior health and safety representative of the organisation.

(f) Health and safety officers and health and safety group shall be empowered by the project manager for stopping any unsafe practices which are of imminent danger to employees. Health and safety group shall directly report to no less than the head of the project.

(g) Health and safety supervisors shall be engaged to assist the health and safety officers in performing their duties.

(h) Management shall provide adequate resources essential to effectively manage the health and safety requirements of the project. The resources shall include human resources, organisational infrastructure, technology and financial resources.

3.5 Design and Engineering

(a) Design drawings, construction methodology and plans shall be reviewed to determine whether any additional risks may arise during the construction due to the features in the design or methodology.

Attention shall be paid to:

(i) Providing permanent hooks and loops for tying safety slings of workers

(ii) Providing holes or such arrangements to the structure to which safe working platforms and safety nets can be connected

(iii) Significant risks from construction materials, which cannot be avoided in the design

(iv) Laying permanent slings, grab rails/bars to be used by the workers

(v) Permanent provision for attaching railings

(vi) Provision for alternative access to the trapped or distressed workers

(vii) Provision for communication

(viii) Design facilitating barricading of the area around work site without causing hindrance to building functional activities

(ix) Durability of such safety related permanent design integrated elements

(x) Other safety practices required for the type of woks involved.

(b) Analysis of design and integration of safety measures, as described above, should be undertaken as value engineering through multi-stakeholder consultation, necessarily involving designers, owner/ client, operation/maintenance management and construction agency.

(c) While need for special work methodology and enabling infrastructure is considered to make conditions safe for construction, attention shall also be drawn to the safety during maintenance operations (including inspections which may be necessary before project commissioning as well as maintenance).

(d) It shall also be ascertained whether it would be feasible (within the time and cost considerations) to erect necessary temporary enabling infrastructure. If, in the due assessment by the project manager, it is established that the design, as proposed, would continue to be unsafe during construction and maintenance operations unless special

enabling infrastructure is created and work procedures specifically drawn, the design shall be reviewed.

3.6 Construction Planning

(a) Prior to the start of construction work, detailed planning shall be carried out which may include:

(i) Identifying aspects of design that have bearing on health and safety during construction stage.

(ii) While scheduling the various activities of the construction, allowing adequate time to carry work in accordance with health and safety requirements.

(iii) Reviewing the proposed work method of various activities, identifying health and safety hazards of activities in the project and assessment of the risk level.

(iv) When the risk level is unacceptable, taking additional control measures including revision of the work methodology so that identified risk is at ALARP (as low as reasonably practicable) level.

(v) Planning and establishing the facilities for implementation of health and safety such as workmen training facility, health centre for medical check-up and first aid, access control of employees, etc.

(vi) Ensuring that the temporary establishments at project site such as site offices, workmen camps, toilets, canteens and rest sheds, etc. are created meeting the requirements of the relevant statutes and standards.

(b) Facility shall ensure that the construction agency has understood the challenges and has planned to meet the project specific health and safety requirement through appropriate competencies.

(c) Health and safety measures need proper coordination by the construction agency and such efforts of the construction agency shall be reviewed, monitored and appropriately guided by the facility.

(d) In respect of sub-contractors, project manager of the construction agency shall ensure that the sub-contractors meet the health and safety requirements of the project. Health and safety control and monitoring shall be established specific to the needs of the project.

(e) Past health and safety performance and capability of contractors to complete the job safely shall be given due consideration during selection of contractors. The project specific health and safety

requirements shall be clearly communicated to the contractors and a commitment obtained from them on meeting the requirements.

3.7 Safety Communication

(a) Procedures shall be established to communicate significant hazards and risks to and from employees and other interested parties. The health and safety hazards and risks may be communicated in the following ways:

(i) Sharing of accidents case studies which occurred in the project site as well in other similar projects

(ii) Health and safety posters and displays

(iii) Health and safety campaigns and competition involving the employees

(iv) Sharing of results of the audits, inspections and other monitoring systems

(v) Establishing a system for collecting feedback on health and safety from employees and other interested parties

(vi) Tool box meeting

(vii) Safety signage.

(b) Health and safety communications addressed to workmen shall preferably be in local language(s) understandable by majority of the workmen.

(c) The owner/client, consultant and construction agency shall jointly endeavour to promote a positive health and safety culture at the project. Top management of the organisations should exhibit a visible management commitment and felt leadership towards health and safety. This shall be achieved by participating in health and safety programmes such as,

(i) Project health and safety committee meeting

(ii) Health and safety walk down

(iii) Including health and safety in all performance review meetings

(iv) Exhibiting a safe behaviour while at site.

(d) The top management should clearly communicate that it considers safety as core value and it shall not allow it to get compromised. Such messages when it reaches down the level in the organisation enable to create a positive health and safety culture.

3.8 Safety Monitoring Programme

(a) The objective of the safety surveillance programme should address

assurance of effective implementation of safety measures in execution of works. Following surveillance programme should be in place at sites. The safety organisation should monitor, maintain record and follow up for corrective actions.

(b) The surveillance programme should consist of identification of safety related deficiencies and status of corrections thereof, the implementation of protective measures, the safe work practices, human behavior etc.

(c) Specific surveillance should be ensured with respect to testing of equipment, portable power tools, electrical equipment and tools, hand tools, surveillance of material handling equipment, transport equipment, earth moving equipment, gas cylinders etc. to comply with various statutory requirements.

(d) Surveillance on safety awareness and training compliance including induction training, on the job training and refresher training, job specific pre-job briefing, job hazard analysis, etc. as per facility's guidelines should be ensured.

(e) Safety related deficiencies should be detected by any employee of the facility and communicated by the safety officer to their line managers with a record and corrective measures monitored and recorded. The engineer-in-charge should specifically ensure this. These should be informed to Head, Industrial Safety within the stipulated time period as per the category of safety related deficiencies (SRDs).

(f) Systematic record of safety related deficiencies (SRDs) attended and pending should be made by the facility and other executing agencies.

(g) Head, Industrial Safety should verify periodically, at least once in 15 days that all safety related work permits issued are executed and recorded.

(h) The health and safety performance monitoring and measurement procedures shall provide for:

  (i) Both qualitative and quantitative measures appropriate to the project

  (ii) Monitoring the extent to which project health and safety objectives are met

(iii) Proactive measures of compliance that measures compliance with health and safety plan, operational control procedures and legislation

(iv) Reactive measures of performance to monitor accidents, ill health, near misses and non-conformances

(v) Monitoring dangerous occurrances

(vi) Fire occurrances

(vii) First aid injuries.

(i) Health and safety audit is a systematic and independent examination to estimate if planned arrangements and activities are effectively fulfilling organisation's health and safety policy, plan and objectives. Its purpose is to find out:

(i) Whether the organisation has adequate procedures for identifying specific health and safety requirements

(ii) Whether such laid down procedures are followed and specific health and safety responsibilities are understood

(iii) Whether health and safety policies and risk assessment procedures identify the measures needed to avoid risks to employees and other interested parties

(iv) Whether the company has adequate procedures for devising, reviewing its health and safety standards

(v) Whether the company's health and safety standard identifies measurable targets

(vi) Whether the company has established adequate procedures for planning, implementing, controlling, monitoring and reviewing the health and safety measures.

(j) Project health and safety management audits provide the method for monitoring and controlling health and safety activities and procedures throughout the life of the project. Audits can be internal or external. Internal audit can be conducted by the persons from the same organisation who are not directly connected with the work site to be audited. The external audits are performed through external professional experts.

(k) Health and safety inspections shall be preferably conducted by a team of the concerned engineer, health and safety officer and area in-charge. Project manager and other senior personnel shall also join in some of the health and safety inspections.

(l) The type of inspections that shall be carried out and the frequency shall be decided during the planning stage and documented in the project health and safety plan. The health and safety inspections should include:

(i) General site health and safety inspection

(ii) Electrical safety inspection

(iii) Plant and machinery inspection

(iv) Health and hygiene inspection

(v) Scaffolding safety inspection

(vi) Portable tools and tackles

(vii) Lifting tools and tackles

(viii) Fire equipment inspection

(ix) Illumination level and noise level monitoring

(m) Project health and safety committee shall be constituted with project manager as the chairman, health and safety head as the secretary and representatives from various groups including workmen representatives as the members. The constitution and functioning of the committee shall meet the provisions of *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996.

(n) This committee shall review the status of implementation of project health and safety plan, health and safety objectives and targets. Health and safety indicators and findings of the walk down by the committee members shall also be discussed and action plan derived.

(o) Status of health and safety implementation shall be measured and monitored by several proactive indicators which include the following:

(i) Compliance level of project health and safety plan

(ii) Compliance level of health and safety observations with in the target date

(iii) Implementation status of training plan

(iv) Implementation status of corrective and preventive actions

(v) Compliance level of pre-employment medical checks and periodic medical checkups

(vi) Compliance level of legal and other requirements

(vii) Percentage of activities for which detailed project specific risk assessment is conducted.

(p) Procedures shall be established to report, investigate and analyze incidents. The procedures shall involve:

(i) Members of the incident investigation team

(ii) Agencies to be reported in case of incidents

(iii) Time period within which incidents need to be reported

(iv) Methodology for investigation and determining the root cause of accidents.

These procedures shall form a part of the project health and safety plan and monitored on a regular basis for its effectiveness.

(q) All incidents including near miss cases, accidents and dangerous occurrences shall be thoroughly investigated, direct and root causes determined and corrective action planned. Incidents should be analysed covering the following ways to prepare and implement an effective prevention plan:

(i) Body part injured

(ii) Age of the victims

(iii) Time of accidents

(iv) Causes of accidents

(v) Nature of injury.

For detailed guidelines on analysis of incidents and computation of injury rate refer IS 3786.

(r) The following reactive health and safety indicators should be used to measure and monitor the health and safety performance of the project site:

(i) Number of near miss cases

(ii) Number of first aid cases

(iii) Lost time injury frequency rate

(iv) Lost time injury severity rate.

(s) The health and safety performance of contractors shall be monitored on a regular basis and necessary directive and support shall be given to achieve the set health and safety objectives and targets.

(t) All accidents leading to property damage/fatal accidents/personnel injuries/near miss and dangerous occurrence should be reported to the engineer-in-charge immediately.

(u) All 'near-miss' accidents should also be recorded/reported and investigated and recommendations arising out should be implemented on priority.

(v) Facility/Contractor should also submit a monthly statement of accidents to engineer-in-charge/head, industrial safety by 4th of the following month showing details of accident, nature of injury including disability, days lost, treatment required, etc. and the extent of property damage.

3.9 Training/Orientation

(a) It shall be ensured that all employees are competent to perform the assigned work safely on the basis of appropriate education, training or experience. The competency requirements of different categories of employees shall be mapped and procedures shall be implemented to ensure that those deployed meet the competence requirements.

(b) Training needs of the different category of employees shall be identified at the beginning of the project and a training matrix and plan shall be prepared for implementation.

(c) The objective of health and safety training shall be to equip the employee with necessary knowledge and skill to perform the work assigned to him in a safe manner, to foster continual improvement and to imbibe safety culture.

(d) Preferably, the training should be carried out away from the working place of the participants to ensure focused attention on the training for both trainer as well as trainees.

(e) After completion of training due procedure shall be followed for obtaining the feedback from the participants on the effectiveness of the training. Effectiveness of training imparted shall be monitored for continual improvement and necessary corrections in implementation.

(f) The training/orientation programme should be implemented to meet the mandatory requirements. [Rule 43(2) (m) of the Atomic Energy (Factories) Rules 1996]. The training should be phased as follows:

(g) Induction cum orientation training should include the overall safety aspects of the work and give a general overview of the various hazards, the particular activities and the do's and don'ts. As a part of training, workers should also be given demonstrations on use of

personal protective equipment, first aid, fire-fighting equipment, fire mock drills, other emergency preparedness etc.

(h) The line manager along with the safety representative should conduct pre-job briefing on day-to-day basis prior to specific hazardous jobs. This will make the workers aware of the hazards and the precautions to be taken.

(i) Refresher training should be imparted to each worker at least once in a year.

(j) A training schedule should be prepared by the facility for implementation.

(k) Records of training, demonstration and pep talk should be maintained.

3.10 Permit to Work System

(a) Activities requiring permit to work shall be decided before starting the construction and shall be suitably documented in the project health and safety plan. Some of the activities which should require permit to work are:

(i) Excavation

(ii) Entry into confined spaces

(iii) Electrical work (HV/LV)

(iv) Opening manholes, covers and grills

(v) Blasting operation

(vi) Hot work

(vii) Work on plant and machinery & other power driven equipment

(viii) Working at height

(ix) Working at night

(b) The facility should establish a permit to work system for any other hazardous activity, which it feels necessary to be controlled administratively for safe execution.

(c) Record of safety work permit should be maintained in a systematic manner. All the safety conditions and requirements stipulated in the safety work permit should be ensured strictly.

(d) Occupier should ensure that only authorized personnel are deployed for hazardous works/jobs (Refer item 3.11 for hazardous job) and provide facilities for the same.

3.11 Job Hazard Analysis

(a) It should be ensured that a safe work procedure exists for all the hazardous jobs as mentioned hereunder and the requirements of the safety procedures are ensured at the work sites. Job hazard analysis (JHA) should form a part of such safe work procedures. A checklist based on JHA should be prepared. This checklist should be crosschecked by the line managers and verified by safety officer.

Typical list of jobs requiring job hazard analysis (this list is illustrative only and not exhaustive) is as follows:

(i) Excavation

- (a) Blasting including under water blasting
- (b) Earth and stone removal/backfilling/dumping of earth/stones
- (c) Any excavation more than 1.8 m depth.

(ii) Work at height (working beyond 3.5 meters above ground)

- (a) Erection and dismantling of scaffolding, platforms, shuttering/ de-shuttering work
- (b) Dome work, rod bending, construction of chimney and cooling towers
- (c) Working on tower crane.

(iii) Materials and material handling

(A) Critical equipment handling e.g.

- (a) Calandria
- (b) Steam generators
- (c) Turbine generator components
- (d) Diesel generator set
- (e) Generator stator
- (f) End shields
- (g) Fuelling machines components
- (h) Heat transport pumps etc.

(B) Hazardous chemical handling e.g.

- (a) Acids and alkalis
- (b) Chlorine

(c) Hydrazine

(d) Morpholine

(e) Freon

(f) Ammonia

(g) LPG

(C) Movement of heavy material by crane

(D) Movement of tractor trolley on slopes

(E) Manual lifting of heavy material to height

(F) Erection of heavy machinery, equipment.

(iv) Electrical connection

(a) Field connection for electrical installation

(b) Installation of lighting fixtures

(c) Charging of electrical system

(i) Charging of transformer, switch yard, switch gears

(ii) Working near high voltage lines

(iii) Use of portable electrical tools.

(v) Equipment/structural erection work

(a) Material handling

(b) Loading and unloading

(c) Transportation of material from one place to other

(d) Steel fabrication and erection

(e) Cleaning and maintenance of batching plant equipment.

(vi) Finishing/painting work

(a) Painting at height

(b) Painting in confined space.

(vii) Other specific work

(a) Work with pneumatic tools/compressed air

(b) Work on pressure vessels/lines

(c) Work in the vicinity of steam lines

(d) Work in high enthalpy area

(e) Work in high noise area

(f) Work in confined space including tunnels & trenches

(g) Work in isolated area (away from main site)

(h) Radiography work

(i) Work related to welding, gas cutting, grinding

(j) Working near conveyor, rotating machine

(k) Leak detection testing.

3.12 Reward and Reprimand

(a) It is important to acknowledge and encourage good health and safety performance and suitably reprimand repeated violations, non-conformances and poor health and safety performances. Project specific reward and reprimand system shall be prepared as a part of the project health and safety plan.

(b) To motivate the employees and organisation to work safely measures can be implemented based on the suitability. Selection and rewarding for the following categories may be considered on regular basis:

(i) Safest workmen

(ii) Safest supervisor

(iii) Safest area

(iv) Safest contractor, etc.

(v) Contractors and employees may be rewarded when the project achieves significant million man-hours without any lost time injury.

(c) Unsatisfactory health and safety performance in the form of repeated violations, frequent adverse incidents and accidents shall be dealt with firmly. Depending on the seriousness of the violation the following options shall be considered:

(i) Issue of violation memorandum and obtaining written commitment for safe working

(ii) Suspension or termination of the employee from the present work

(iii) Suspension or termination of contract in case of construction agency

(iv) Imposition of penalty to the construction agency.

(d) When penalties are imposed due records shall be maintained in a transparent manner. The main contractor shall be responsible wherever he deploys sub-contractor/petty contractor/piece rate contractor. The funds thus accrued may be spent in the form of rewarding employees for their sincere efforts towards improving the health and safety performance.

4. WORK SPECIFIC SAFETY SAFETY MEASURES

4.1 General

(a) The occupier should ensure that safety precautions are taken during the execution of awarded work and work areas are maintained safe at all times. At the end of each shift and at all times when the work is suspended, it should be ensured that the work area is left safe in such a way that no materials and equipment that can cause damage to existing property, personal injury or interfere with the other works of the project or station are left in an unsafe manner.

(b) The occupier should ensure to provide and maintain all lights, guards, fencing, warning signs, caution boards and other safety measures and provide for vigilance as and when necessary for the protection of workers and for the safety of others. The caution boards should also have appropriate symbols.

(c) Adequate lighting facilities such as floodlights, hand lights and area lighting should be provided at the site of work, storage area of materials and equipment and temporary access roads within the working area.

(d) All works should be planned so as to avoid interference with other facilities, works of other contractors or sub-contractors at the site. In case of any interference, necessary coordination should be ensured for safe and smooth working.

(e) It should be ensured that the instructions given by the safety officer or his designated nominee regarding safety precautions, protective measures, housekeeping requirements, etc. are complied with. The safety officer with due intimation to engineer-in-charge should have the right to stop the work, if in his opinion, proceeding with the work will lead to an unsafe and dangerous condition. Engineer-in-charge should arrange to get the unsafe condition rectified and/ or provide appropriate protective equipment.

(f) Engineer-in-charge should ensure that each job with a hazard whether small or big is intimated to the safety officer of the facility well before it is taken up.

(g) The facility should be fully responsible for non-compliance of any of the safety measures or requirements, implications, injuries, fatalities, dangerous occurrences and compensation arising out of such situations or incidents.

(h) Maximum duty hours of an individual should be as per the Factories Act 1948 or its latest amendment.

(i) Illumination levels should be as per the statutory requirements.

4.2 Rock Blasting

(a) All blasting operations should be carried out on the basis of procedures approved by Head, industrial safety and engineer-in-charge. All works in this connection should be carried out as per BIS specification/code (IS 4081: 1986. Title:- Safety code for blasting and related drilling operations (First Revision)). Barricades, warning signs etc. should be placed on the roads/open area.

(b) Blasting permit should be obtained from Head, industrial safety at least one day before the blasting operation and precautions mentioned there in shall be ensured by the engineer-in-charge before blasting operation.

(c) The blaster should have a licence from competent authority under Explosive Rules, 1983 for blasting work. It should also be ensured that he knows about the risks involved.

(d) Blasting should be done under the supervision of competent engineer/ supervisor.

(e) Blasting in the open site should only be carried out during fixed hours every day/fixed day in the week between sunrise and sunset. Residents of adjacent area should be informed in advance about the blasting schedule.

(f) No blasting should be undertaken during thunderstorm.

(g) Necessary precaution should be taken to ensure the stability/integrity/ safety of the adjacent structure by limiting the peak particle velocity.

(h) No loose material, such as tools, drilling equipment, etc. should be left on the surface to be blasted. Proper muffling arrangement of the blasting area should be ensured to avoid flying of blasted material.

(i) Authorised blaster should personally ensure that all the personnel/ equipment has been removed from the blasting area before the blasting operations.

(j) Blasting area should be free of detonating gas, inflammable objects, sparking or damaged wiring system, stray currents and static electricity.

(k) All electrical lines in blasting area should be de-energised.

(l) Entry of unauthorised personnel should be prevented by displaying warning signs.

(m) In case of misfire, no person should be allowed to approach the blasting site unless it is inspected and cleared by a competent engineer/supervisor.

(n) Explosives and blasting material should be stored only in clean, dry, well-ventilated, suitably constructed bullet/ magazine which should be fire resistant and securely locked. Stock book should be kept accurate and maintained. Licence should be obtained for storage of explosive as per the Explosives Act, 1884.

(o) Blasting caps, electric blasting caps or primers and detonators should not be stored in the same box, container or room with other explosives.

(p) Precautions against lightening should be provided in accordance with Indian Electricity Rules, 1956 (amended in 2000).

(q) The explosives should be transported in specially designed vehicles bearing a special sign or inscription entitled 'DANGER - EXPLOSIVES'. Also detonators separated from other explosive should be transported in a separate compartment.

4.3 Excavation, Trenching and Earth Removal

(a) Before taking up excavation work, necessary permission should be obtained from the engineer-in-charge with reference to existing underground services.

(b) The engineer-in-charge of the works should exercise full care to ensure that no damage is caused by him or his workmen, during the operation/excavation etc., to the existing water supply, sewerages, power or telecommunication lines or any other services or works. He should provide and erect before construction, substantial barricades, guardrails, and warning signs around the work area. He should also furnish, place and maintain adequate warning lights, display board, signals etc., as required.

(c) All trenches 1.2 m or more in depth should at all times be supplied with at least one ladder for every 30 m along the trench. Ladders shall extend from bottom of the trench to at least 1 m above the surface of the ground.

(d) The sides of the trench/pit in soil, which are 1.2 m or more in depth should be stepped back to give suitable slope (angle of repose) or securely held by timber bracing or appropriate shoring/support, to avoid the danger of soil slides from collapsing. The excavated material should not be placed within 1.5 m or half of the depth of the pit whichever is more from edges of the trench/pit. Cutting should be done from top to bottom. Under no circumstances mining or under-cutting should be done.

(e) Workers should not be exposed to the danger of being buried by excavated material or collapse of shoring. Measures to prevent dislodgment of loose or unstable earth, rock or other material from falling into the excavation by proper shoring shall be ensured.

(f) The stability and safety of the excavation, adjacent structures, services and other works should be ensured.

(g) All excavated area should be fenced off by suitable railing and installation of caution board to warn the persons from slipping or/ falling into the excavation pit/ mound.

(h) All excavated areas shall have an illumination level of at least 20 lux for night work and a red danger light shall be displayed at prominent place near the excavation site to warn approaching traffic and men.

(i) For removal of earth from an earth mound/excavated heap a written permission should be obtained from the engineer-in-charge of the work. As far as practical, earth should be removed mechanically. Wherever manual removal of earth is involved, earth should be removed from the top by maintaining a slope equal to the angle of re-pose of the earth. Such work should be constantly supervised to ensure that no under-cutting is done and to ensure that no person is trapped.

(j) Dumping of excavated soil should be done at a specified area under proper supervision with respect to signaling, illumination and safety clearance.

(k) It should be ensured that at a construction site of a building or other construction work, every vehicle or earth moving equipment is equipped with a) silencers, b) tail lights, c) power and hand brakes, d) reversing alarm e) search light for forward and backward movement, which are required for the safe operation of such vehicle or earth moving equipment and f) the cab of the vehicle or earth moving equipment is kept at least one meter from the adjacent face of a ground being excavated. g) indicator etc.

(l) It should be ensured that when a crane or shovel is traveling, the boom of such crane or shovel is in the direction of such travel and the bucket or scoop attached to such crane or shovel is raised and without load, except when it is traveling downhill.

(m) Before loading or unloading power trucks or trailers attached to tractors, the brakes should be applied and if vehicle is on a sloping ground, the wheels should be blocked. Handcart should not be used for the transfer of construction/erection materials in the construction

area. However if the exigency demands urgent transfer of light materials a small handcart may be permitted with the prior approval of the engineer-in-charge.

(n) It should be ensured that at a construction site of a building or other construction work:

(i) All transport or earth moving equipment and vehicles are inspected at least once in a week by responsible persons and in case any defect is noticed in such equipment or vehicle, it is immediately taken out of service.

(ii) Safe gangways are provided for to and fro movement of building workers engaged in loading and unloading of lorries, trucks, trailers and wagons.

(iii) All earth moving equipment, vehicles or other transport equipment be operated only by such persons who are adequately trained and possess such skills as required for safe operation of vehicles or other transport equipment.

(iv) Trucks and other equipment are not loaded beyond their safe carrying capacity, which should be clearly marked on such trucks and other equipment.

(v) No unauthorised person rides the transport equipment employed in such work.

(o) It should be ensured at a construction site of a building or other construction work that:

(i) A shovel or an excavator whether operated by steam or electric or by internal combustion used for such work is constructed, installed, operated, tested and examined as required under any law for the time being in force and the relevant national standards.

(ii) Buckets or grabs of power shovels are propped to restrict the movement of such bucket or grabs while being repaired or while the teeth of such bucket or grabs are being changed.

(p) It should be ensured at a construction site of a building or other construction work that:

(i) An operator of a bulldozer before leaving – applies the brakes, lowers the blade and ripper and puts the shift lever into neutral.

(ii) A bulldozer is parked on level ground at the close of the work.

(iii) The blade of a bulldozer is kept low when such bulldozer is moving uphill.

(iv) Bulldozer blades are not used as brakes except in an emergency.

(q) It should be ensured at a construction site of a building or other construction work that:

(i) A tractor and a scraper are joined safely at the time of its operation

(ii) The scraper bowls are propped while blades of such scraper are being replaced.

(iii) A scraper moving downhill is driven in low gear.

(r) It should be ensured at a construction site of a building or other construction work that:

(i) Before a road roller is used on the ground, such ground is examined for its bearing capacity and general safety, especially at the edges of slopes such as embankments on such grounds.

(ii) A roller is not moved down hill with the engine out of gear.

(s) Vehicle carrying excavated material should have proper cover over the driver's cabin.

4.4 Safe Means of Access/Platforms

(a) Adequate safe means of access and exit should be provided for all work places, at all elevations.

(b) Suitable scaffolds should be provided for workmen for all works that cannot be done safely from the ground, or from solid platform except such short duration work that can be done safely from ladders. Bamboo/wooden scaffolding should not be permitted.

(c) Where the platform for working is more than 3.5 m above ground, the width of the platform should be minimum 1 m.

(d) Ladder should be of rigid construction having sufficient strength for the intended loads. Wooden/bamboo/rope ladders should not be permitted. All ladders should be maintained in good condition. The ladders should be fixed to the ground or rigid platforms. An additional person should be engaged for holding the ladder, if ladder is not securely fixed. Ladder shall be extended from floor to at least one meter above the platform.

(e) A portable ladder should be given an inclination not steeper than 1 in 4 (1 horizontal and 4 vertical). Ladders should not be used for climbing while carrying materials in hands. While climbing both the hands should be free.

(f) Any working platform on scaffolding or staging more than 3.5 m above the ground or floor should have a guard rail attached, bolted, braced at least 1 m high above the floor or platform of such scaffolding or staging along with mid-rail.

(g) The planks used for any working platform should not project beyond the end supports to a distance exceeding four times the thickness of the planks used. The planks should be rigidly fixed at both ends to prevent sliding, slipping or tilting. The thickness of the planks should be adequate to take load of men and materials and should not collapse. Plywood or packing wood should not be used as planks.

(h) The guardrail should extend along the entire exposed length of the scaffolding with only such opening as may be necessary for the delivery of materials. Standard railing should have posts not more than 2 m apart and an intermediate rail halfway between the floor or platform of the scaffolding and the top rail. Such scaffolding or staging should be so fastened as to prevent it from swaying from the building or structure. Scaffolding and ladder should conform to IS 3696 (Part 1): 1987 and (Part II): 1996.

(i) Working platforms of scaffolds should have toe boards at least 15 cm in height to prevent materials from falling down.

(j) A sketch of the scaffolding proposed to be used should be prepared and approval by the engineer-in-charge obtained prior to start of erection of scaffolding. All scaffolds should be examined by engineer-in-charge before use.

(k) Working platform, gangways and stairways should be so constructed that they should not sag unduly or unequally and if the height of the platform or gangway or stairway is more than 3.5 m above ground level or floor level. They should have adequate width for easy movement of persons and materials and should be suitably guarded.

(l) No single portable ladder should be used for access to a height of more than 4.5 m. For ladders up to 3m in length the width between styles (side bars)/width in the ladder should in no case be less than 300 mm. For longer ladders this width should be increased by at least 20 mm for each additional meter of length. Step/rungs spacing should be uniform and should not exceed 300 mm. Portable ladder should be used only for access to work place. In case work place is higher than 4.5 meters, pre-fabricated steel staircase should be used.

4.5 Work at Height

(a) Person to work at height should be medically fit and should have height pass issued by safety section. (Appendix A Part A, B and C). Safety training should be imparted before working at height.

(b) Safety work-permit system for working at height should be obtained from industrial safety section.

(c) At elevated places, secure access and foothold should be provided. Adequate and safe means of access and exit should be provided at all work places for all elevations. Means of access may be portable or fixed ladder, ramp or a stairway. The use of crosses, braces or framework, as a means of access to the working platform should not be permitted.

(d) Linear movement at height should be reduced to minimum. In case of such movement provision for anchoring the safety belt should be made.

(e) Where barricades cannot be installed, a safety net of adequate strength should be installed close to the level at which there is a danger of fall of personnel/fall of objects.

(f) In case where 'work at height' is on asbestos roof, crawling board, roof ladder should be used to walk across the asbestos roof.

4.6 Electrical Safety

(a) All electrical installations shall comply with the appropriate statutory requirements given below and shall be subject to approval of the electrical engineer and safety officer.

(i) The Electricity Act, 2003

(ii) The Indian Electricity Rules 1956 (as amended in 2000)

(iii) The National Electricity Code 2008

(iv) Atomic Energy (Factories) Rules, 1996

(v) Other relevant rules of statutory bodies and power supply authority

(vi) Relevant standards of BIS

In addition to the above statutory provisions, the clauses indicated in this document shall also be complied.

(b) It shall be the responsibility of the user seeking temporary power supply to indicate in writing, if any of the clauses (requirements noted in above regulations and in this document) are conflicting with each other and for which the user cannot decide the course of action regarding safe installation, commissioning, operation, maintenance and decommissioning of the electrical installations.

(c) The electrical engineer and safety officer of the facility providing temporary power supply shall interpret the concerned conflicting clauses and approve in writing the safe course of action.

(d) The Application Form-1 (Form-1A, 1B and 1C) as mentioned in Appendix-B should be submitted by the user for getting the temporary power supply.

(e) After installation of temporary electrical panels, wiring works by the user, certificates as per Form-1D (Appendix-B) should be submitted to the provider.

(f) Certificate of safety officer and authorisation of electrical engineer for energisation of temporary power supply should be filled as per Form-1E (Appendix-B).

4.7 Material Handling and Lifting Machines and Tackles

(a) It should be made compulsory to supervise jobs like lifting/placing/loading/unloading/carrying/transporting etc. of heavy material by qualified supervisor having knowledge about hazards involved and precautions to be taken for such job.

(b) The line managers should ensure that the material handling equipment used is adequate to handle the load.

(c) Manual pulling of heavy equipment and trolley loaded with heavy material is not to be permitted.

(d) Stacking and handling of heavy materials should be done on a firm ground to prevent settlement.

(e) No lifting machine and no chain, rope or lifting tackle, except a fiber rope or fiber rope sling, shall be taken into use in any factory for the first time in that factory unless it has been tested and all parts have been thoroughly examined by a competent person. A certificate of such a test and examination specifying the safe working load or loads and signed by the person making the test and the examination has been obtained and is kept available for inspection.

(f) Use of lifting machines and tackles should conform to relevant BIS requirements [IS 13367 (Part 1): 1992 Reaffirmed 2003, IS 4573: 1982 (Reaffirmed 2000) and IS 13834 (Part 1): 1994 Reaffirmed 2003 etc. The accessories and the attachments, anchorages and supports etc. should be ensured in healthy conditions by regular inspections at defined frequencies.

(g) Every rope used in hoisting or lowering materials or as a means of suspension should be of good quality and adequate strength and free

from any defect. This should be ensured by regular inspection as per IS 2762: 1982- Specification for wire rope slings and sling legs (first revision).

(h) Every crane operator or lifting appliance operator should be authorised. No person under the age of 18 years should be in charge of any hoisting machine or give signal to an operator of such machine.

(i) In case of every lifting machine (and of every chain, ring, hook, shackle, swivel and pulley block used in hoisting or as a means of suspension) the safe working load should be ascertained and clearly marked. In case of a lifting machine having a variable safe working load, each safe working load and the conditions under which it is applicable should be clearly indicated. No part of any machine should be loaded beyond the safe working load except for the purpose of testing. This should be approved by the engineer-in-charge and head, industrial safety.

(j) In case of facilities machines, the safe working load should be notified by the engineer-in-charge. As regards the contractor's machines, the contractor should declare the safe working load of the machine to the engineer-in-charge whenever he brings any machinery to site of work and get it verified by the engineer-in-charge, supported by a valid test certificate by the competent person.

(k) Thorough inspection and load testing of lifting machines and tackles should be done in the presence of competent person at least once in every 12 months and records of such inspections and testing should be maintained.

(l) No mobile crane should be allowed to move under live high-tension power transmission line.

(m) While lifting loads, cranes should be located on level ground.

(n) A thorough load analysis should be carried out before using cranes in tandem.

(o) Motors, gear transmission, couplings, belts, chain drives and other moving parts of hoisting appliances should be provided with adequate safeguards. Hoisting appliances should be provided with such means, which will reduce the risk of any part of a suspended load becoming accidentally displaced or lowered.

(p) It should be ensured that the cabin of the lifting machine in outdoor service:

(i) is made of fire resistant material,

(ii) has a suitable seat, a footrest and protection from vibration,

(iii) affords the operator an adequate view of the area of operation,

(iv) affords the operator adequate protection against the weather, and

(v) is provided with fire extinguisher.

4.8 Welding and Gas Cutting

(a) Welding and gas cutting operations should be done by qualified and authorized persons only.

(b) Safety work permit should be obtained (wherever necessary like presence of flammable or combustible material etc.) before flame cutting/welding is taken up.

(c) Welding and gas cutting should not be carried out in places where flammable or combustible materials are kept and where there is danger of explosion due to presence of gaseous mixtures. In case the requirement cannot be avoided, specific approval and procedure should be ensured and adequate precautions should be taken.

(d) Welding and gas cutting equipment including hoses and cables should be maintained in good condition.

(e) Barriers should be erected to protect other persons from harmful rays from the work. When welding or gas cutting is done in elevated positions, precautions should be taken to prevent sparks or hot metal falling below on persons or combustible materials.

(f) Suitable type of protective clothing consisting of fire resistant gauntlet gloves, leggings, boots and aprons should be provided to workers as protection from heat and hot metal splashes. Face shields with filter glasses of appropriate shade should be worn.

(g) Adequate ventilation should be provided while welding, brazing and cutting the metals like zinc, brass, bronze, galvanised or lead coated material.

(h) Welding and gas cutting on drums, barrels, tanks or other containers should be taken up only after ascertaining that they have been emptied, cleaned thoroughly and made free of flammable material.

(i) Fire safety measures should be available as required near the location of welding/cutting operations.

(j) Flash back arrestor should be provided with gas cutting and gas welding sets.

(k) For electric (Arc) welding the following additional safety precautions should be taken:

(i) When electrical welding is undertaken the return lead of welding machine should be directly connected to the job invariably.

(ii) Provision must be in place in electric welding machine to prevent physical contact with live parts.

(iii) The welding cables and power cables should be routed separately to avoid entanglement.

(iv) The electric welding set should have suitable earth connections. There should be an electrical isolation device in the input power supply side on the welding machine.

(l) Double gauges should be used for all gas cylinders used for cutting/ welding. Pressure gauges/regulators should be in healthy condition.

4.9 Rotary Cutters/Grinders

(a) All portable cutter/grinders should be provided with the wheel guard in position.

(b) Grinding wheels of specified diameter only should be used on all grinders in order to limit the prescribed peripheral speed.

(c) In pedestal grinder, the gap between tool rest and grinding wheel should be maintained less than 3 mm.

(d) Goggle/face shield should be used during grinding operation.

(e) No grinding wheel should be used after its expiry date.

(f) Ear muff/ear plug should be used during the welding/cutting jobs.

(g) Portable appliances, which are powered by single phase AC supply, shall be provided with three-core cable and three pin plug, otherwise the whole body should be double insulated.

(h) Safety work permit should be obtained (wherever necessary like presence of flammable or combustible material etc.) before grinding is taken up.

(i) Fire safety measures should be available as required near the location of grinding operations.

4.10 Concrete Mixing Equipment

(a) Cement bags should be stacked on wooden planks in dry and leak proof area, 150 mm to 200 mm from the floor and 450 mm away

from walls. Height of the stack should not be more than 15 bags or 1.5 meters which ever is lower. Width of the stack should not be more than 4 bags or 3 meters. Lateral loading of the walls of the storage room by stacking should not be permitted. Stacking of the bags should not be used as a working platform.

(b) Shuttering and supporting structures should be of adequate strength and approved by engineer-in-charge. This should be ensured before concrete is poured.

(c) If the mixer has a charging skip the operator should ensure that the workmen are out of danger before the skip is lowered.

(d) Adequate walking platforms (as per the AERB directives) are to be provided in the reinforcement area to ensure safe walking for pouring concrete on the roof.

(e) When workmen are working/cleaning the inside of the drum of mixer, the power of the mixer should be switched off and "Do not operate" tag should be provided. The plant operation and cleaning of mixing pan should be carried out as per equipment supplier's instructions.

(f) Interlocks between the cover and the mixer rotor shall be established to ensure that the agitator does not start when the cover is in open condition.

(g) It should be ensured that moving parts of the elevators, hoists, screens, bunkers, chutes and grouting equipment used for concrete work and of other equipment used for storing and transporting of ingredients of concrete are securely fenced to avoid contact of workers with such moving parts.

(h) It should be ensured that screw conveyors used for cement, lime and other dusty material are completely enclosed.

(i) Workers engaged for handling bulk cement in a confined place should be provided with tight fitting goggle, approved respirators and protective clothing, which will fit snugly around the neck, wrist and ankles.

(j) The following should be ensured for every pipe carrying pumped concrete:

    (i) The scaffolding carrying a pipe for pumped concrete should be strong enough to support such pipe at a time when such pipe is filled with concrete or water or any other liquid and to bear safely all the building workers who may be on such scaffold at such time.

(ii) Securely anchored at its end point and each curve on it.

(iii) Provided with an air release valve near the top of such pipe; and securely attached to a pump nozzle by a bolted collar or other adequate means.

(k) The following should be ensured while using the electric vibrators in concreting work at a construction site of a building or other construction work such that:

(i) Such vibrators are earthed.

(ii) The leads of such vibrators are heavily insulated.

(iii) The current is switched off when such vibrators are not in use.

(l) For obtaining a clearance for first pour of concrete and regular operation of ready mix concrete (RMC) plant, checklist given in Appendix-C shall be submitted to AERB along with the application for clearance.

4.11 Painting

(a) Appropriate breathing air respirators should be provided for use by the workers when paint is applied in the form of spray, or a surface having lead paint is dry rubbed or scraped.

(b) Only the quantity of paint, thinner and polish required for the day's work should be kept at the work spot. Excess storage should not be permitted at the work spot.

(c) Smoking, open flames or sources of ignition should not be allowed in places where paints, varnish, thinner and other flammable substances are stored, mixed or used. A caution board, with the instructions written in national language and regional language, 'SMOKING - STRICTLY PROHIBITED' should be displayed in the vicinity where painting is in progress or where paints are stored. Symbols should also be used on caution boards.

(d) All electrical equipment of paint storage room should be of explosion proof design. Suitable fire extinguishers/sand buckets should be kept available at places where flammable paints are stored, handled or used.

(e) When painting work/hot resin mix is done in a closed room or in a confined space, adequate ventilation should be provided and ensured. In addition, suitable respirators should be provided. No portable electric light or any other electric appliance of voltage exceeding

24 volts should be permitted for use inside any confined space. Walkie-talkie or other means of communication should be provided. Rescue arrangement like full body harness with lifeline, tripod with pulley and extra BA sets should be available.

(f) The workers should use PVC gloves and/or suitable barrier creams to prevent the skin contact with Epoxy resins and their formulations used for painting.

4.12 Demolition

(a) Before any demolition work is commenced and also during the progress of the work, all roads and open area adjacent to the work site should either be closed or suitably cordoned. Appropriate warning signs should be displayed for cautioning approaching persons/ vehicles.

(b) Before demolition operations begin, it should be ensured that all the service lines are de-energized.

(c) Persons handling demolition operations shall use appropriate PPE.

(d) All demolition operations should be carried out with safe and duly approved procedures which shall include following but not limited to:

(i) No masonry/material should be permitted to fall in such masses or volume or weight so as to endanger the structural stability of any floor or structural support.

(ii) No wall, chimney or other structure or part of a structure is left unguarded in such a condition that it may fall, collapse or weaken due to wind pressure or vibration.

(iii) No floor, roof or other part of the building should be overloaded with debris or materials as to render it unsafe.

(e) After the demolition, the debris and other materials collected should be disposed safely and not permitted to be dropped freely.

(f) Entries to the demolition area shall be restricted to authorised persons wearing safety helmets and safety shoes.

4.13 Traffic

(a) All the vehicles moving at sites should conform and comply with the requirements of Motor Vehicles Act, 1988 and the Rules made there under. All the drivers/operators of vehicles should possess valid driving license as per Motor Vehicles Act, 1988 or its latest amendment.

(b) The facility should conduct operations so as to interfere as little as possible with the use of existing roads at or near locations where the work is being performed. When interference to traffic is inevitable such as road cutting or transit unloading of heavy equipment etc. notice of such interference should be given to the engineer-in-charge and safety officer well in advance with the details of start of the work and time required.

(c) A cleaner/assistant must be available for all heavy vehicles whenever vehicles move forward as well as in the reverse direction. All vehicles should be fitted with proper reverse horns, back view mirrors and indicator signals.

(d) Facility should ensure that the assessment of the driver's visual ability is carried out as per Rule 55 of the Atomic Energy (Factories) Rules, 1996/guidelines of advisory committee on occupational health (ACOH), AERB or as per the latest amendments in statutes.

(e) Effective speed breakers with yellow stripes on the roads to regulate the speed at the vulnerable points should be installed. Effective barricading with adequate caution signs should be placed to warn the vehicle drivers whenever the jobs are carried out on the road.

(f) All vehicles moving at the site should have roadworthiness certificate issued by the concerned authority.

(g) Special limit boards and caution boards indicating turns should be installed wherever necessary.

(h) In general, the following maximum speed limits should be specified and implemented. Vehicles speed limits should be as per Motor Vehicle Act or 20 Km/h. Extra precautions and care should be exercised particularly during heavy material/equipment movements.

(i) Safety awareness programmes should be conducted for all the drivers of the light, medium and heavy vehicles.

4.14 Work in Radiation Area

The facility should follow the stipulated procedure under Atomic Energy Radiation Protection Rules, 2004 and AERB safety manual on 'Radiation Protection for Nuclear Facilities' (AERB/NF/SM/O-2) regarding work in the radiation area and other works related with radiography.

4.15 Work in and Around Water Bodies

(a) When work is done at a place where there is risk of drowning, all necessary rescue equipment such as life buoys and life jackets should be provided and kept ready for use.

(b) All necessary steps shall be taken for prompt rescue of any person in danger and adequate provision should be made for prompt first-aid treatment of all injuries likely to be sustained during the course of the work. Proper record of entry/exit to and from water bodies shall be maintained on shift basis and search operation shall be conducted as soon as any person is detected to be missing.

(c) Caisson Work

(i) Safe means of access should be provided to the place of work in the caisson and adequate means should be provided to safely reach the top of caisson in the event of inrush of water

(ii) The work relating to construction, positioning, modification or dismantling of caisson shall be done under the supervision of a responsible person

4.16 Fire Safety

(a) All provisions for fire safety shall be complied as per AERB safety standard on 'Fire Protection Systems for Nuclear Facilities' [AERB/NF/SS/FPS (Rev. 1)].

(b) All necessary precautions should be taken to prevent outbreak of fires at the construction site. It should be ensured that all hot work is carried out under valid work permit.

(c) Combustible materials such as wood, cotton waste, oil, coal, paints, chemicals etc., should be segregated and kept to the required bare minimum quantity at work place.

(d) Containers of paints, thinners and allied materials should be stored in a separate room which should be well ventilated and free from excessive heat, sparks, flame or direct rays of the sun. The containers of paint should be kept covered or properly fitted with lid and should not be kept open except while using.

(e) Adequate number of trained persons from approved fire training centre required to extend fire safety coverage should be ensured.

(f) Fire extinguishers as approved by the engineer-in-charge/in-charge of fire station/safety-in-charge should be located at the construction site at appropriate places.

(g) Adequate number of trained workmen in fire fighting who can operate fire extinguishers should be ensured.

(h) Portable fire extinguishers with periodic inspection, maintenance and re-filling complying with the mandatory requirements should be ensured.

(i) Availability of adequate water for fire fighting should be ensured.

(j) Implementation of the provisions of various statutory licenses for storing gas cylinders, petroleum products, explosives etc. as per the relevant acts and rules should be ensured wherever required.

4.17 Environmental Safety

Relevant provisions of the state/central statutory authority regarding environment protection should be adhered to.

4.18 Public Protection

The Facility should make necessary provisions to protect the public. He should be bound to bear the expenses in defense of every action or other proceedings at law that may be brought by any person for injury sustained owing to neglect of any precaution required to be taken to protect the public. He should pay for the any such damage and cost which may be awarded in any such suit, action or proceedings to any such person, or the amount, which may be fixed as a compromise by any such person.

4.19 Safety of Visitors

(a) Visitors for the project shall be given health and safety induction before they are allowed in to the construction project. It shall include the minimum PPE to be used, hazards and risks at the work area, restricted areas of entry, emergency response arrangements, etc.

(b) Visitors shall always be accompanied by one of the employees of the project site.

(c) Visitors shall not be allowed in the hazardous areas unless they are competent and trained to work in such areas.

4.20 Housekeeping

(a) It should be recognised that a proper place for everything and everything in its place is maintained for a good housekeeping.

(b) The material required for immediate use only should be brought to the designated workplace and stacked properly and labeled suitably.

(c) All work spots, site office and surroundings should all times be kept clean and free from debris, scrap, concrete muck, surplus materials and unwanted tools and equipment. A day-to-day collection and disposal of scraps/debris should be done safely at designated place.

(d) Electrical cables, leads and hoses should be so routed as to allow safe traffic by all concerned. Cable should be preferably supported on the brackets fixed along the wall to maintain safe access. Wherever

routing on the floor cannot be avoided, care should be taken to ensure mechanical protection of these cables and safe access is not disturbed.

(e) No material on any work place should be so stacked or placed or disposed off as to cause danger, inconvenience or damage to any person or environment.

(f) All unused scaffoldings, surplus/scrap materials and equipment/ systems like temporary electrical panels etc. should not be allowed to accumulate and shall be removed from the premises at the earliest.

(g) Accumulation of water/oil spillages on the floor or any other workplace should be avoided.

(h) Proper aisle space marking should be provided in all workplaces.

4.21 Other Statutory Provisions

Notwithstanding the clauses in the above subsections, there is nothing in these clauses to exempt the Facility from the provisions of any other act or rules in force in the Republic of India. In particular, all operations involving the transport, handling, storage and use of explosives should be as per the standing instructions and conform to the Indian Explosives Act, 1884 and the Explosives Rules, 1983. Handling, transport, storage and use of compressed gas cylinders and pressure vessels should conform to the Gas Cylinder Rules 2004 and Static and Mobile Pressure Vessels (Unfired) Rules 1981. In addition, The Indian Electricity Act 2003 and Indian Electricity Rules 2005, the Atomic Energy Act, 1962, the Radiation Protection Rules, 2004, the Atomic Energy (Factories) Rules, 1996 and AERB safety manual on 'Radiation Protection for Nuclear Facilities' (AERB/NF/SM/O-2) should be complied with.

5. PERSONAL PROTECTIVE EQUIPMENT

5.1 General

Although the primary approach in any safety effort is that the hazard to the workmen should be eliminated or controlled by engineering methods rather than protecting the workman through use of personal protective equipment (PPE). Engineering methods could include design change, substitution, ventilation, mechanical handling, atomisation etc. Under those situations when it is not possible to introduce any effective engineering methods for controlling hazards, it is necessary that workman use appropriate type of PPE. For example, in construction work there is the possibility of a hand tool, a bolt, or some loose material to fall from an elevated level and striking the head of workman working below. It is therefore necessary that construction worker wear a safety helmet. It is for such situations, both the Factories Act 1948 and the Atomic Energy (Factories) Rules, 1996 have provisions for use of appropriate type of PPE.

It is thus recognised that use of PPE is an important and necessary consideration in the development of a safety programme. Once the safety professional decides that PPE is to be used by workmen, it is essential to select right type of PPE and management should ensure that workman uses it and also PPE is correctly maintained.

5.2 Personal Protective Equipment (PPE)

(a) All personal protective equipment as considered necessary should be made available for the use of the persons employed on the site and maintained in a condition suitable for immediate use. Also adequate steps should be taken by engineer-in-charge to ensure proper use of PPE.

(b) All the PPEs in use should be as per relevant IS standards as referred in the AERB safety guidelines on 'Personal Protective Equipment' (AERB/SG/IS-3).

(c) All persons employed at the construction site should use safety helmets. Safety helmet should be with BIS mark and should have its headband with back support and chin strap.

(d) Workers employed on mixing asphaltic materials, cement and lime mortars should use protective goggles, protective foot wears, hand gloves and respirators as required.

(e) Persons engaged in welding and gas-cutting works should use suitable welding face shields. The persons who assist the welders should use suitable goggles. Protective goggles should be worn while chipping and grinding.

(f) Stonebreakers should use protective goggles. They should be seated at sufficiently safe distances from one another.

(g) Safety goggles should be of shatterproof type and with zero power.

(h) Persons engaged in or assisting in shot blasting operations and cleaning the blasting chamber should use suitable gauntlets, overalls, shatterproof and dust-proof goggles and self contained breathing apparatus set.

(i) All persons working at heights more than 3.5 m above ground or floor and exposed to risk of falling down should use full body harness safety belts, unless otherwise protected by cages, guard railings, etc. In places where the use of safety belts is not feasible, suitable net of adequate strength fastened to substantial supports should be used.

(j) When workers are employed in sewers and inside manholes that are in use, it should be ensured that the manholes are opened and are adequately ventilated at least for an hour. After it has been well ventilated, the atmosphere inside the space should be checked for the presence of any toxic gas or oxygen deficiency by a competent person and recorded in the register before the workers are allowed to get into the manholes. A pilot team should enter the area donning self contained breathing apparatus (SCBA). The manholes opened should be cordoned off with suitable railing and provided with warning signals or caution boards to prevent accidents. There should be proper illumination in the night. Depending upon the work situation, the facility should provide PPE including the SCBA as recommended by Head, industrial safety.

6. MEDICAL MANAGEMENT

6.1 General

(a) The facility management/contractor shall make arrangements for the first aid and medical services for the injured or ill persons for prompt attention or aid.

(b) The arrangement can be made by the contractor or an agreement can be in vogue with the facility .

(c) The medical facilities at first-aid centre shall be adequate to immediately cater to the injured based on the hazard potential and probable severe injuries.

(d) The first aid centre shall be provided with the adequate equipment and medicines for catering to the site requirements. The first aid centre shall be manned depending on the working hours/on round the clock shift basis. The services of at least one qualified medical practitioner (medical officer) shall be made available by the Facility management/contractor.

6.2 Medical Facilities

(a) Medical facilities conforming to the provisions of the Atomic Energy (Factories) Rules, 1996 should be provided at all work sites.

(b) The requisite medical facilities in the form of a well-equipped first aid centre manned by qualified nursing personnel should be provided at all work sites. Contractor may avail this facility as per terms and conditions of the contract.

(c) In addition, well-maintained first aid boxes should be kept at each location of the work by the Facility/contractor and availability of the personnel trained in first aid should be ensured.

(d) A manned and equipped ambulance should be available at work site during the working hours/on round-the-clock shift basis.

(e) It should be ensured by the occupier that occupational health monitoring of contract workers is carried out as per provisions of the Factories Act 1948 as per the latest amendment and the stipulations/directions given by Atomic Energy Regulatory Board from time to time.

(f) Display of emergency contact numbers of important persons and hospitals and route map of site shall be maintained at designated places.

6.3 Medical Management of Serious Injuries

(a) In case of serious injuries, the injured should be shifted to the nearest first-aid centre at site immediately. The opinion of medical officer/ certifying surgeon should be sought immediately for medical management.

(b) After providing the first aid treatment the injured should be shifted to designated medical facility of the site/hospital for further medical assistance, in an ambulance along with a nursing attendant.

(c) The doctor at the medical facility of the site/hospital attending the case shall assess the extent of injuries and render immediate medical aid. If the situation warrants trauma/special care the injured shall be shifted to the referral hospital, having all the requisite facilities for specialised treatment in ambulance along with a medical attendant.

(d) A list of such referral hospitals for specialised medical management facilities for the injured persons should be available with the project management/Head, industrial safety and Head, medical services of the site for ready reference.

APPENDIX-A

APPLICATION FOR HEIGHT PASS

PART- A

Group/Section: _____

Agency: _____

1. Applicant's Name : _____
2. Facility address : _____
3. Residential address : _____
4. Age : _____
5. Sex : _____
6. Height : _____
7. Gate Pass No. : _____
8. Name of contractor/agency with whom engaged at present : _____
9. Height pass required for work at _____ m. Height
10. Description of present job : _____
11. Previous experience of working at height :

S.No.	Name of the Employer	Duration of Employment	Work Experience
1.			
2.			

12. Does the applicant suffer from any of the following ailments? (If yes details to be given):

    (a) Blood pressure _____ (b) Epilepsy _____

    (c) Flat foot _____

    (d) Frequent headache or reeling sensation _____

    (e) Mental depression _____ (f) Limping gait _____

    (g) Aerofobia _____

Declaration:

I hereby declare that the above information furnished by me is true and correct. I shall always wear the safety belt and tie the life-line whenever working at unguarded heights of 3 m and above. I shall not misuse the height pass issued to me or transfer it to any other person. I shall never come to duty or work at height/depth under the influence of alcohol/drugs.

Date: Name:

Sign:

(Applicants name and signature or loss time injury (L.T.I) incase he cannot sign. In case of LTI an authorised person shall explain each point/item to the individual and certify on that behalf below the LTI)

I certify that I am satisfied with the above certification of the individual for the application of height pass and request for issue of height pass to him.

Name :

Sign :
(Agency Concerned)

Countersigned by:

Section Head (Facility)

PART- B

MEDICAL FITNESS CERTIFICATE

Certified that I, Dr. _____ have examined Shri _____ _____ aged _____ on (date) _____ who has signed below in my presence. General & physical examinations of Shri. _____ _____ do not reveal any abnormality. He does not suffer from any acute/ chronic skin disease or any contagious or infectious disease. His eye sight is normal with/without glasses. In my opinion, Shri _____ is physically and mentally fit for working at height.

Details of examinations are given below:

Personal attributes:

1. Height: _____
2. Chest: _____
3. Weight: _____
4. Hearing: _____
5. Sight: _____
6. Skin: _____
7. Heart beating: _____

Medical aspects:

1. Urine: _____
2. Blood pressure: _____
3. Epilepsy: _____
4. Flat foot: _____
5. Frequent headache or reeling sensation: _____
6. Mental depression: _____
7. Limping gait: _____
8. Aerophobia: _____

Name:

Sign :

Rubber Stamp of
Medical Practitioner
with Reg. No.

Signature of workman:

PART-C

INDUSTRIAL SAFETY SECTION

(Considering the above medical certificate, the applicant has appeared on the following practical tests conducted by industrial safety section and the results are given below (strike off whichever is in-applicable)

(a) Wearing a safety belt and tying the rope knot : Pass/fail

(b) Walking over a horizontal structure at 3 m. height wearing a safety belt : Pass/fail

(c) General physique (OK/Not OK)

The above applicant's performance in the above tests has been satisfactory/ unsatisfactory due to the following.

So I certify and issue this height pass to Shri _____ with Registration No. _____ in the height pass register. This is valid for one year from the date of issue i.e. up to _____

Date:

Name:

Sign.:
Scientific Assistant (Safety)

Safety Officer

APPENDIX-B

FORM - 1

APPLICATION FOR TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION

[Prescribed under clause 4.6(d)]

1.	Name and address of user.	
2.	Reference of tender or work order (if applicable)	:
3.	Name & designation of tender/work order issuing authority.	:
4.	Power supply application number†	:
5.	Name and designation of tender/work order/work supervising authority (engineer-in-charge).	:
6.	Expected date of commencement of temporary supply	:
7.	Expected date of decommissioning of temporary supply	:
8.	Voltage level (LV/MV/HV)	
9.	Type of connection (1Ph/3Ph)	
10.	Connected load (Kw)	
11.	Maximum demand (KVA)/Power factor	
12.	Single line diagram* of proposed power distribution scheme along with equipment data sheet (downstream installation after point of connection).	Enclosed (Form-1A)/Not enclosed
13.	Name of overall supervisor and available qualified Staff	Enclosed (Form-1B)/Not enclosed
14.	Auxiliary equipment data sheet (meters, fire extinguisher, first aid box etc)	Enclosed (Form-1C/Not enclosed
15.	Name and designation of provider's representative to whom the application is addressed.	:
16.	Name and designation of authorized signatory of user, who had submitted this application	:

† Power supply application number shall be different for same user with multiple applications for temporary supply

* All the drawings and tables shall be signed by user's representative indicated against 16 above.

Signature of authorised signatory of user

Signed endorsement of work order supervising authority indicated against 5 above.

FORM - 1A

EQUIPMENT DATA SHEET FOR OBTAINING TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION

(Prescribed against item-12 of form-1)

Name and address of user:

Power supply application Number:

Amendment No:-

References:- Single line diagram (SLD) of the power distribution scheme with all equipment details (Attach the SLD)

1. Identity	2. Type	3. Make & model	4. Manufacturer's S.No	5. Fixed/ Portable	6. Size	7. Last used date	8. Last test date	9. Latest test data	10. Rating

Signature of authorised signatory of user

Explanation of column headers:

1. Identity:- Identification mark/number/tag of equipment in single line drawing and layout drawing. Every equipment in single line drawing and layout drawing shall have suitable identification mark/number/tag.
2. Type:- Cable/CB/MCB/MCCB/ELCB/transformer/lightning arrestor/earthing station/ earthing connection/motor/lighting fixture/switch/fuse/switch, socket box etc.
3. Make and model:- manufacturer's name and corresponding model no.
4. Manufacturer's S. No:- serial number and date in name plate if available. Else NA
5. Fixed/portable:- Equipment is installed/laid/anchored to surface or portable.
6. Size:- depending upon type of equipment and as desired by provider representative e.g. length for cables or all dimensions if heavy equipment like transformer.
7. Last used date. date of last use else NEW
8. Last test date. latest test date by user or by manufacturer if NEW
9. Latest test data:- IR, HV, resistance, functional test data depending upon the type of equipment as desired by provider's representative.
10. Rating:- name plate rating of equipment like voltage, current, power (apparent, active, reactive), IP of enclosure, size(cable cross section) etc. depending upon the type of equipment and as desired by provider's representative.

FORM - 1B

STAFF DATA SHEET FOR OBTAINING TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION
(Prescribed against item-13 of form-1)

Name and address of user:

Power supply application Number:
Amendment No:-

1. Name	2. Address	3. Tel.No.	4. Responsibility	5. Certification detail	6. Resucitation training	7. Expe-rience	8. Other relevant training	9. Signature

Signature of authorised signatory of user

Explanation of column headers:

1. Name:- Name of agency/person
2. Address:-
3. Tel No:- regular, alternate and emergency telephone numbers
4. Responsibility:- whether responsible for installation, operation, maintenance, overall supervision etc. overall supervisor shall be indicated specifically.
5. Certification detail:- (a) type of certification e.g wire man license, electrical supervisor license, electrical contractor license, diploma in electrical engineering, degree in electrical engineering etc. (b) certifying agency e.g. state PWD, central PWD, CEA, name of college/university etc. (c) certificate/license number with date. (d) valid up to date or next renewal date must for contractor/supervisor license.
6. Artificial resuscitation training:- indicate YES/NO if the staff is trained to apply artificial resuscitation technique.
7. Experience.:- number of years of experience.
8. Other relevant training :- any other training in electrical/safety course. Indicate name of training, duration (days/months), training providing agency.
9. Signature:- original signature of individual.

FORM - 1C

AUXILIARY EQUIPMENT DATA SHEET FOR OBTAINING TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION
(Prescribed against item-14 of form-1)

Name and address of user:

Power supply application Number:
Amendment No:-

Reference:- Layout drawing No. / _____

1. Identity	2. Type	3. Make and model	4. Manufacturer's S. No	5. Fixed/ Portable	6. Size	7. Last used date

Signature of user's representative

Explanation of column headers:

1. Identity:- identification mark/number/tag of equipment in layout drawing.
2. Type:- earthing rod/megger/multi meter/earth resistance meter/fire extinguisher/s and bucket/first aid box/resuscitation chart/rubber mat etc.
3. Make and model:- manufacturer's name and corresponding model no.
4. Manufacturer's S. No:- serial number and date in name plate if available. Else NA
5. Fixed/portable:- equipment is installed/laid/anchored to surface or portable.
6. Size:- depending upon type of equipment and as desired by provider representative.
7. Last used date. NEW for new equipment. NA for passive devices like chart/mat etc.

FORM-1D

[Prescribed under clause 4.6(e)]

Name of user agency **Power supply application number:-**

CERTIFICATE BY THE LICENSED ELECTRICAL CONTRACTOR

Certified that subject installations have been carried out by us or checked by us and is in accordance with I.E. Rules. The documents submitted with subject temporary power supply application (Form-1) is verified by us and the complete installation confirms to these documents.

We shall periodically inspect/check the installation so that no unsafe situation arises during use of this temporary power supply system. We understand that for the entire duration of existence of this temporary power supply system we shall be responsible for any unsafe installation, operation, maintenance, testing of the same which results into any loss of life or material. We shall immediately report to the provider's representative and ensure de-energisation of supply if any unsafe situation arises during use of this temporary power supply system.

Signature of the authorised signatory of licensed electrical contractor

Rubber seal of licensed electrical contractor

Date

CERTIFICATE BY THE USER

Certified that my/our installations have been carried out in accordance with the I.E. Rules and that I/We have employed competent agency/staff to handle the installations which is strictly as per the staff data sheet submitted in Form-1B.

We understand that for the entire duration of existence of this temporary power supply system we shall be responsible for any unsafe installation, operation, maintenance, testing of the same which results into any loss of life or material. We shall immediately report to the provider's representative and ensure de-energisation of supply if any unsafe situation arises during use of this temporary power supply system.

Signature of the authorised signatory of user

Name of signatory

Date

FORM -1E

[Prescribed under clause 4.6(f)]

CERTIFICATE BY THE SAFETY OFFICER

Certified that I have inspected the electrical installation referred here in after satisfying myself about the safe condition of the installation, I hereby recommend that the service connection be given to the contractor.

Signature of the safety officer

Name:

Date:

AUTHORISATION BY THE ELECTRICAL ENGINEER

The subject power supply application along with completed installation, necessary certificates (as per Form-1 of Appendix-B) is scrutinised by us. The proposal found to be in order and the installation can be energised on _____ in presence of your designated overall supervisor as indicated in Form-1B. Enclosed herewith the test report data sheet Form-1F. You are requested to carry out the periodic testing of equipment and submit the test report periodically as per this form.

Signature of the electrical engineer
of provider

Name of signatory

Date

FORM - 1F

TEST/MAINTENANCE REPORT DATA SHEET OF EQUIPMENTS OF TEMPORARY POWER SUPPLY SYSTEM AT WORK SITE DURING CONSTRUCTION
(Prescribed against form-1E)

Name and address of user:

Power supply application Number:
Amendment No:-

1. Identity	2. Type	3. Last tested date	4. Next due date of any test	5 Frequency of IR test	6 Frequency of HV test	7. Frequency of earth resistance test	8. Other tests

Signature of electrical engineer of provider

Explanation of column headers:

1. Identity:- identification mark/number/tag of equipment in single line drawing and layout drawing. Every equipment in single line drawing and layout drawing shall have suitable identification mark/number/tag.
2. Type:- Cable/ CB/ MCB/ MCCB/ ELCB/transformer/lightning arrestor/earthing station/ earthing connection/motor/lighting fixture/switch/fuse/switch, socket box etc.
3. Last test date: - latest test date indicated in Form-1A.
4. Next due date of any test:- as worked out by frequency of tests indicated in subsequent columns.
5. Frequency of IR test:- required frequency depending upon type of equipment and location of installation. NA if not required after installation.
6. Frequency of HV test:- required frequency depending upon type of equipment and location of installation. NA if not required after installation.
7. Frequency of earth resistance test:- required frequency depending upon type of equipment and location of installation. NA if not required after installation.
8. Other tests: - name and description of any other essential tests/maintenance activity and required frequency depending upon type of equipment and location of installation. NA if not required after installation.

APPENDIX-C

CHECKLIST FOR OPERATION OF READY MIX CONCRETE (RMC) PLANT

(To be submitted to AERB along with application for construction consent and a copy to be retained by site)

(Verifiable documents like supplementary checklists, work sheets, spread sheets etc. should be maintained for each item of the checklist wherever relevant)

Serial No.	Points to be Checked	Remarks
1. 0	**Prior to Installation of the RMC Plant**	
1.1	Whether acceptance report on healthiness of the pre-identified critical plant equipment like concrete mixer, pumps, programmable logic controllers, conveyors, etc. prior to installation available ?	
1.2	Whether approval for the location of the plant site after evaluation and review by project management available ?	
1.3	Whether review of the vendor documents like operation and maintenance manual, vendor specifications, safety manual, etc. of contractor carried out by project management ?	
1.4	Whether job hazard analysis reports, erection procedures, checklists for critical activities available ? Are the operators aware of it ?	
1.5	Whether adequate number of line managers/supervisors/ operators for carrying out the jobs safely are identified and availability is ensured ?	
1.6	Whether safety surveillance requirements of construction activities both by contractor and facilities clearly spelt out?	
1.7	Whether adequate work control measures like construction permit, safety work permit system, height pass system, etc. for safe job performance are available ?	
1.8	Whether any facilities officer is assigned the responsibility of the RMC Plant ?	
2.0	**Commissioning/Operation of RMC Plant**	
2.1	Whether reports on healthiness of material handling equipment like hoists, belt conveyors, buckets, hoses, including electrical equipment etc. are available ?	

APPENDIX-C (CONTD.)

CHECKLIST FOR OPERATION OF READY MIX CONCRETE (RMC) PLANT

Serial No.	Points to be Checked	Remarks
2.2	Whether machine guards for pulleys, power shafts, rollers, etc. are available ?	
2.3	Whether availability of safe operating procedures, emergency procedures, process diagrams, power supply diagrams, details of interlocks, operation & maintenance manual (provided by supplier/vendor) ensured ?	
2.4	Whether adequate number of qualified, trained and experienced operators for safe operation of the plant including mechanism/method of operational control and command available ?	
2.5	Whether periodic surveillance programme for equipment, logics, interlocks, process parameters, trips, noise and illumination levels, etc. and measures to take corrective actions are available ?	
2.6	Whether periodic checks are carried out to ensure display of all interlocks and warning signals in PLC monitor ?	
2.7	Whether operations control measures like log sheets, work permits, procedures, instruction sheets, by-passing/jumpering trips, etc. are available ?	
2.8	Whether access to medical first-aid box & fire extinguishers, etc. available ?	
3.0	**Operating/Working Areas**	
3.1	Control Room	
3.1.1	Whether adequate information on process equipment and parameters, logics and control available ?	
3.1.2	Whether clear view of the plant from the control room to check entry of personnel into operating areas is available ?	
3.1.3	Whether availability of distinct window panels to distinguish process parameters, alarms and trips are verified ?	
3.1.4	Whether audio alarm is available in the field to give warning prior to starting of concrete mixer & conveyor belt ?	
3.1.5	Whether relevant operating and maintenance documents available and accessible ?	

APPENDIX-C (CONTD.)

CHECKLIST FOR OPERATION OF READY MIX CONCRETE (RMC) PLANT

Serial No.	Points to be Checked	Remarks
3.1.6	Whether operational controls preventing re-setting of operational parameters, trips by-passing, logic changes, etc. are available in control room ?	
3.1.7	Whether operational data and information logged chronologically indicating the status of equipment running & shutdown, maintenance works planned and taken up.	
3.1.8	Whether means of communication between operator and control room are available ?	
3.2	**Aggregates Storage/Handling Areas**	
3.2.1	Whether aggregates/materials stored separately in suitable weatherproof enclosures ?	
3.2.2	Whether routes for movement of vehicles clearly defined ?	
3.2.3	Whether reverse horns, rear view mirror, etc. on all dumpers/ trailers/trucks are provided ?	
3.2.4	Whether machine guards for rotating/moving/conveying machines available in place ?	
3.2.5	Whether engineered noise control measures available in the crushing areas ?	
3.2.6	Whether usage of ear muffs for ear protection in noisy areas enforced ?	
3.2.7	Whether trip/emergency stop switch/pull cord mechanisms, etc. to the moving/rotating equipment like belt conveyors, crushers etc. are available and healthy ?	
3.2.8	Whether adequate dust control measures in working areas available ?	
3.2.9	Whether adequate illumination is provided in the working areas ?	
3.2.10	Whether safety/warning sign boards available to prevent persons approaching operating crushers/belt conveyors etc ?	
3.3	**Storage Hoppers/Silos**	
3.3.1	Whether suitable access with handrails to reach to the top of hoppers/silos provided ?	

APPENDIX-C (CONTD.)

CHECKLIST FOR OPERATION OF READY MIX CONCRETE (RMC) PLANT

Serial No.	Points to be Checked	Remarks
3.3.2	Whether proper walk ways with guard railing to access to different storage areas available ?	
3.3.3	Whether measures to prevent clogging of equipment like air fluidiser, etc. are available ?	
3.3.4	Whether controls and safety measures for feeders like belt conveyors to the silos/hoppers, etc. is available ?	
3.3.5	Whether dust suppression and noise control measures are in place ?	
3.3.6	Whether safety measures to enter into silos/hoppers for operation/maintenance requirements.	
3.3.7	Whether safe access for sampling locations/areas and procedure for collecting the samples are available ?	
3.4	**Concrete Mixer Areas**	
3.4.1	Whether safe access and working platform in mixing area provided ?	
3.4.2	Whether safe condition of the mixers, pumps, etc. used in the areas is ensured ?	
3.4.3	Whether proper identification tags for equipment, pipelines etc. are available ?	
3.4.4	Whether safe condition of the electrical equipment like local push buttons, panels, cables etc. ensured ?	
3.4.5	Whether adequate illumination in the working areas is ensured ?	
3.4.6	Whether interlocks of Mixers are in healthy state ?	
3.4.7	Whether sand bin is provided with electro-mechanical vibrator for easy material flow ?	
3.4.8	Whether warning signals to prevent persons approaching operating mixers in place ?	
3.4.9	Whether proper storage of admixtures to prevent freezing and availability of material safety data sheets for admixtures and other chemicals are ensured ?	
3.4.10	Whether collection trays have been provided under overhead conveyor belt to prevent fall of material ?	

APPENDIX-C (CONTD.)

CHECKLIST FOR OPERATION OF READY MIX CONCRETE (RMC) PLANT

Serial No.	Points to be Checked	Remarks
3.4.11	Whether the mixing cylinder/drum has emergency manual discharge facility ?	
4.0	**Electrical Safety**	
4.1	Whether proper isolating switches/isolators are provided for all equipment in the field as well as in control room ?	
4.2	Whether proper grounding/earthing arrangement for all electrical installations metallic structures and panel boards provided and recording of earth pit resistance values planned ?	
4.3	Whether fuses of adequate rating are available to limit overloading of circuits ?	
4.4	Whether earth leakage circuit breakers in all circuits are provided and tested periodically to ensure their healthiness ?	
5.0	**Particulate Emissions**	
5.1	Whether provisions of measurement of particulate emissions are available ?	
5.2	Whether actions to be taken in case of more visual emissions are available ?	
5.3	Whether methods to prevent/control spread of dust in working areas available ?	
6.0	**General Requirements**	
6.1	Whether emergency services like fire station, first aid, hospital etc accessible ?	
6.2	Whether specific line staff/supervisors for carrying out routine, special and emergency works with certain instructions and communications identified and trained ?	
6.3	Whether do's and don'ts while handling refrigerants like ammonia and admixtures used in concrete mixing displayed promptly ?	
6.4	Whether the use of personal protective equipment like helmet, safety belt, self contained breathing apparatus/canister, hand gloves, apron, face shield, safety shoes, gumboots etc. has been ensured ?	

APPENDIX-C (CONTD.)

CHECKLIST FOR OPERATION OF READY MIX CONCRETE (RMC) PLANT

Serial No.	Points to be Checked	Remarks
6.5	Whether emergency procedures to be followed during ammonia leaks, fires, etc. are available ?	
6.6	Whether fire extinguishers are available at various critical locations ?	

PART-B

CONTROL OF WORKS
(CONTRACTORS)

7. INTRODUCTION

7.1 General

The Department of Atomic Energy(DAE) through its constituent units execute various site works either by their own manpower or by manpower of various outside agencies. The nature of contracts with outside agencies can be works contracts, engineering procurement contracts, purchase contracts, minor fabrication contracts etc. These site works involve entire gamut of conventional industrial activities like excavation, rock blasting, earth handling, construction, material handling, fabrication, installation, operation, maintenance etc. of nuclear or conventional plants/facilities. This is a challenging responsibility for the contractor due to the complexity of problems like quality of workforce (which may be unskilled, illiterate, migratory) available for labor-intensive jobs, lack of coordination among agencies at site, lack of safety awareness among concerned authorities, time schedules of project etc. As a principal employer, facility management shall be responsible to ensure health and safety of all personnel engaged for the work. In this process, the contractor through his established measures shall ensure that the guidelines are implemented. However the facility management shall monitor the compliance with the provisions outlined in the guidelines through periodic supervision and review. Any accidental injury or loss of life is detrimental to the facility as well as the society. This 'guidelines' covers the safety organisation and the safety management system requirements in sections two and three. The work specific safety precautions are covered in section four. The requirements relating to personal protective equipment and medical management are covered in sections 5 and 6.

7.2 Objective

This 'guidelines' has a basic framework of industrial safety organisation, safety management systems, safe work procedures to maintain a safe working environment for all personnel and to prevent any unsafe condition/act endangering the life of personnel engaged for industrial activities. The major objectives of this 'guidelines' are:

(i) To create awareness among workers about industrial hazards and safe working procedures.

(ii) To lay down safe work procedures and systems to be followed for different type of industrial activities.

(iii) To establish a robust safety management system.

(iv) To protect the health and ensure the safety of the workers from industrial activities.

7.3 Scope

This ‘guidelines’ is essential for implementation and assurance of conventional safety in areas such as industrial, chemical, electrical, fire, environmental and is applicable for all works executed through contracts, like engineering procurement contract, minor fabrication contract etc. Where the execution of work is envisaged in radiation controlled area or involves handling and fabrication of any nuclear material, additional precautions noted in relevant AERB safety documents on radiation protection shall also be applicable.

8. SAFETY ORGANISATION

8.1 General

(a) Construction projects have significant health and safety hazards, which need to be managed systematically since the project inception stage to achieve incident- free completion of jobs. Contractor should have well-defined safety organisation which helps in effective implementation of safety management systems and ensures health and safety of workers.

(b) The top management of contractor should assure that all the provisions of relevant Acts & Rules are conformed to.

(c) Safety organisation should carry out safety surveillance, safety training, safety enforcement measures, safety audit etc. related to all works to fulfill the overall safety requirements of this 'guidelines'.

(d) Safety functionaries should be exclusively assigned with the work related to protection of health and safety of workers.

(e) IS: 18001: 2007 gives detailed requirements of health and safety management system requirements. IS: 15793 gives requirements of good practices for managing environment, occupational health and safety legal compliance. This 'guidelines' prescribes requirements in addition to IS: 18001:2007 and IS: 15793 and gives guidelines on implementing these specific to a construction project.

(f) The requirements prescribed in various central and state regulations including *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996 and rules framed thereunder with respect to managing health and safety in construction projects, shall be complied with.

8.2 Organisational Structure for Safety Management

(a) The Contractor shall deploy qualified and experienced line management personnel for supervising the jobs to be carried out safely by workers. In order to oversee the industrial and fire safety aspects during execution of hazardous jobs (listed out in para 9.11) by the contractors, at least one safety supervisor with the qualifications and experience mentioned in Table -2 shall be in place irrespective of the man power deployed by the contractor.

(b) The qualification, experience and the minimum number of safety professionals to be deployed by contractor shall be as per the following table:

TABLE-2 : QUALIFICATION, EXPERIENCE AND NUMBER OF SAFETY PROFESSIONALS FOR CONSTRUCTION PROJECTS

Category of safety person	Mandatory requirement	Qualification
Safety officer	One in each shift (minimum) up to 1000 workers. If number of workers in a shift (including contractor's workers) exceeds 1000, additionally one safety officer should be deployed for every 1000 workers or part thereof.	Degree in engineering/ technology and diploma in industrial safety with minimum two years of experience or Diploma in engineering with diploma in industrial safety with minimum 6 years experience or A recognised degree in physics or chemistry and has practical experience of working in a factory in a supervisory capacity for a period of not less than 5 years. Not withstanding the provision contained in the above criteria any person who (i) possesses a recognised degree or diploma in engineering or technology and has had experience of not less than five years in a department of the central or state government which deals with the administration of the Factories Act, 1948 or the Dock Workers (safety, health and welfare) Act, 1986 (54 of 1986) or (ii) Possesses a recognised degree or diploma in engineering or technology and has had experience of not less than 5 years, fulltime on training, education, consultancy, or research in the field of accident prevention in industry or in any institution, shall also be eligible for appointment as a safety officer:

TABLE-2 : QUALIFICATION, EXPERIENCE AND NUMBER OF SAFETY PROFESSIONALS FOR CONSTRUCTION PROJECTS (CONTD.)

Category of safety person	Mandatory requirement	Qualification
		Provided that competent authority may, subject to such condition as it may specify, grant exemption from the requirement of this sub rule if in its opinion, a suitable person possessing the necessary qualification and experience is not available for appointment.
Safety supervisor	One in each shift (minimum) up to 500 workers or One Supervisor for any hazardous job (listed in para 9.11) if, carried out by Contractor irrespective of number of workers. If number of persons working in a shift (including the contractors' workers) exceeds 500, additionally one safety supervisor should be deployed for every 500 workers or part thereof.	Diploma in engineering and diploma in industrial safety

9. SAFETY MANAGEMENT

9.1 General

The construction agencies (contractors) shall be asked to submit a project specific health and safety plan (construction safety management plan) proposing the methodology for managing health and safety and their capability in completing the project in a safe manner.

9.2 Safety Policy

(a) The facility and the construction agency jointly or separately shall have a written statement prescribing the health and safety policy of the organisation. The health and safety policy conveys the management commitment and intent of the organisation towards health and safety, its organisation and arrangements to ensure that the set objectives are met. It also provides a framework for establishing, maintaining and periodically reviewing health and safety objectives and targets.

(b) Health and safety policy shall meet the requirements of *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996 and IS 18001.

(c) The policy shall be communicated to all stakeholders through display and other means. The policy shall be displayed in local language(s) which may be understood by majority of the workmen.

9.3 Safety Plan

(a) A project specific health and safety plan shall be developed by the contractor and approved by the facility. On approval by the facility, health and safety plan shall be reference document for implementation, control and monitoring of health and safety aspects of the project by the Contractor.

(b) Project health and safety plan shall describe how the project specific health and safety objectives and targets shall be achieved. It shall define the road map for achieving the standards that an organisation lays down for itself so that efforts can be coordinated, synergized and monitored.

(c) Health and safety plan shall explain the means of establishing a positive health and safety culture at the project site. Health and safety plan shall identify and enumerate the control measures to mitigate the risks to the project completion arising out of health and safety issues so that the project is allowed to proceed without interruption and executed as per schedule.

Salient aspects that may be covered in the project health and safety plan are:

(i) Project specific health and safety objectives, targets and programmes in line with health and safety policy.

(ii) Hazard identification and risk assessment

(iii) Meeting legal and other requirements

(iv) Health and safety organisation

(v) Resources, roles, responsibility and authority

(vi) General health and safety rules

(vii) Health and safety requirements to be followed by sub-contractors

(viii) Operation control procedure

(ix) Activities requiring work permit system and its procedure

(x) Management of traffic safety inside the project

(xi) Access control of employees

(xii) Safety of visitors

(xiii) Management of critical activities such as work at height, material handling, working with plant and machinery, etc.

(xiv) Safe handling of chemicals, explosives, gas cylinders, electrical equipment etc.

(xv) Ensuring the competency and awareness of the workmen

(xvi) Fire prevention and fire fighting plan

(xvii) Emergency preparedness and response plan

(xviii) Traffic management plan

(xix) Training matrix

(xx) Personal protective equipment matrix

(xxi) Health and safety performance monitoring measures such as inspection and audit

(xxii) Incident reporting and investigation procedure

(xxiii) Proactive and reactive indicators of health and safety

(xxiv) Reward and reprimand for health and safety performance

(xxv) Checklist and formats.

(xxvi) Health monitoring plan for employees/workers exposed to hazardous jobs.

(d) The risk control measures identified shall meet the provisions of *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996, other legislations and provisions of various safety related standards.

(e) Procedures shall be established for timely recording and reporting of information required for continual improvement of health and safety performance.

Internal reporting procedures shall cover:

(i) Incident reporting

(ii) Non-conformance reporting

(iii) Health and safety performance reporting

(iv) Hazard identification reporting

External reporting shall cover

(i) Statutory reporting requirements

The recording of reporting of health and safety performance shall be clearly documented in the health and safety plan.

9.4 Roles, Responsibility and Authority

(a) Contractor shall define, document and communicate the roles, responsibilities and authorities of all personnel who manage, perform and verify activities having an effect on health and safety risks. It shall also include subcontractors and visitors.

(b) The line management personnel who are responsible for execution of activities are directly responsible for health and safety in the work under their control.

(c) Health and safety group and health and safety officers are responsible for guiding the top management of their own organisation on health and safety issues and facilitating the implementation of health and safety in the project site. For duties and responsibilities of health and safety officers refer Atomic Energy (Factories) Rules-1996.

(d) Health and safety supervisors shall be engaged to assist the health and safety officers in performing their duties.

(e) Management shall provide adequate resources essential to effectively manage the health and safety management system requirements of the project.

9.5 Design and Engineering

(a) Design drawings, construction methodology and plans shall be reviewed to determine whether any additional risks may arise during the construction due to the features in the design or methodology.

Attention shall be paid to:

(i) Providing permanent hooks and loops for tying safety slings of workers

(ii) Providing holes or such arrangements to the structure to which safe working platforms and safety nets can be connected

(iii) Laying permanent slings, grab rails/bars to be used by the workers

(iv) Permanent provision for attaching railings

(v) Provision for alternative access to the trapped or distressed workers

(vi) Provision for communication

(vii) Design facilitating barricading of the area around work site without causing hindrance to building functional activities

(viii) Durability of such safety related permanent design integrated elements

(ix) Other safety practices required for the type of woks involved

(x) Significant risks from construction materials, which cannot be avoided in the design.

(b) Analysis of design and integration of safety measures, as described above, should be undertaken as value engineering through multi-stakeholder consultation, necessarily involving designers, owner/ client, operation/maintenance management and construction agency.

(c) While need for special work methodology and enabling infrastructure is considered to make conditions safe for construction, attention shall also be drawn to the safety during maintenance operations (including inspections which may be necessary before project commissioning as well as maintenance).

(d) It shall also be ascertained whether it would be feasible (within the time and cost considerations) to erect necessary temporary enabling infrastructure. If, in the due assessment by the project manager, it is established that the design, as proposed, would continue to be unsafe during construction and maintenance operations unless special enabling infrastructure is created and work procedures specifically drawn, the design shall be reviewed.

9.6 Construction Planning

(a) Prior to the start of construction work, detailed planning shall be carried out which may include:

(i) Identifying aspects of design that have bearing on health and safety during construction stage.

(ii) While scheduling the various activities of the construction, allowing adequate time to carry work in accordance with health and safety requirements.

(iii) Reviewing the proposed work method of various activities, identifying health and safety hazards of activities in the project and assessment of the risk level.

(iv) When the risk level is unacceptable, taking additional control measures including revision of the work methodology so that identified risk is at ALARP (As Low as Reasonably Practicable) level.

(v) Planning and establishing the facilities for implementation of health and safety such as workmen training facility, health centre for medical check-up and first aid, access control of employees, etc.

(vi) Ensuring that the temporary establishments at project site such as site offices, workmen camps, toilets, canteens and rest sheds, etc. are created meeting the requirements of the relevant statutes and standards.

(b) Facility shall ensure that the construction agency has understood the challenges and has planned to meet the project specific health and safety requirement through appropriate competencies.

(c) Health and safety measures need proper coordination by the construction agency and such efforts of the construction agency shall be reviewed, monitored and appropriately guided by the facility.

(d) In respect of sub-contractors, project manager of the construction agency shall ensure that the sub-contractors meet the health and safety requirements of the project. Health and safety control and monitoring shall be established specific to the needs of the project.

9.7 Safety Communication

(a) Procedures shall be established to communicate significant hazards and risks to and from employees and other interested parties. The health and safety hazards and risks may be communicated in the following ways:

(i) Sharing of accidents case studies which occurred in the project site as well in other similar projects

(ii) Safety induction and orientation training

(iii) Health and safety posters and displays

(iv) Health and safety campaigns and competition involving the employees

(v) Sharing of results of the audits, inspections and other monitoring systems

(vi) Establishing a system for collecting feedback on health and safety from employees and other interested parties

(vii) Tool box meeting

(vii) Safety signage.

(b) Health and safety communications addressed to workmen shall preferably be in local language(s) understandable by majority of the workmen.

(c) The facility and construction agency shall jointly endeavour to promote a positive health and safety culture at the project. Top management of the organisations should exhibit a visible management commitment and felt leadership towards health and safety. This shall be achieved by participating in health and safety programmes such as:

(i) Project health and safety committee meeting

(ii) Health and safety walk down

(iii) Including health and safety in all performance review meetings

(iv) Exhibiting a safe behaviour while at site.

(d) The top management should clearly communicate that it considers safety as core value and it shall not allow it to get compromised. Such messages when it reaches down the level in the organisation enable to create a positive health and safety culture.

9.8 Safety Monitoring Programme

(a) The objective of the safety surveillance programme should address assurance of effective implementation of safety measures in execution of works. Following surveillance programme should be in place at sites. The safety organisation should monitor, maintain record and follow up for corrective actions.

(b) The surveillance programme should consist of identification of safety related deficiencies and status of corrections thereof, the implementation of protective measures, the safe work practices, human behavior etc.

(c) Specific surveillance should be ensured with respect to testing of equipment, portable power tools, electrical equipment and tools, hand tools, surveillance of material handling equipment, transport equipment, earth moving equipment, gas cylinders, stores, etc. to comply with various statutory requirements.

(d) Surveillance on safety awareness and training compliance including induction training, on the job training and refresher training, job specific pre-job briefing, job hazard analysis, etc. as per facility's guidelines should be ensured.

(e) Safety related deficiencies (SRDs) shall be detected by any employees/worker of construction agency and communicated to the line manager for corrective actions. The corrective action shall be monitored and records shall be maintained.

(f) Systematic updating of SRDs attended and pending should be made available by the contractor for verification of facility.

(g) The health and safety performance monitoring and measurement procedures shall provide for:

  (i) Both qualitative and quantitative measures appropriate to the project

  (ii) Monitoring the extent to which project health and safety objectives are met

  (iii) Proactive measures of compliance that measures compliance with health and safety plan, operational control procedures and legislation

  (iv) Reactive measures of performance to monitor accidents, ill health, near misses and non-conformances

  (v) Monitoring dangerous occurrences

  (vi) Fire occurrences

  (vii) First aid injuries.

(h) Health and safety inspections shall be preferably conducted by a team of the concerned engineer, health and safety officer and area in-charge of the contractor.

(i) The type of inspections that shall be carried out and the frequency shall be decided during the planning stage and documented in the project health and safety plan. The health and safety inspections should include:

(i) General site health and safety inspection

(ii) Electrical safety inspection

(iii) Plant and machinery inspection

(iv) Health and hygiene inspection

(v) Scaffolding safety inspection.

(vi) Portable tools and tackles

(vii) Lifting tools and tackles

(viii) Fire equipment inspections

(ix) Illumination level and noise level monitoring

(j) Status of health and safety implementation shall be measured and monitored by several proactive indicators which include the following:

(i) Compliance level of project health and safety plan

(ii) Compliance level of health and safety observations with in the target date

(iii) Implementation status of training plan

(iv) Implementation status of corrective and preventive actions

(v) Compliance level of pre-employment medical checks and periodic medical checkups

(vi) Compliance level of legal and other requirements

(vii) Percentage of activities for which detailed project specific risk assessment is conducted.

(k) Procedures shall be established to report, investigate and analyze incidents. The procedures shall involve:

(i) Members of the incident investigation team

(ii) Agencies to be reported in case of incidents

(iii) Time period within which incidents need to be reported

(iv) Methodology for investigation and determining the root cause of accidents.

These procedures shall form a part of the project health and safety plan and monitored on a regular basis for its effectiveness.

(l) All incidents including near miss cases, accidents and dangerous occurrences shall be thoroughly investigated, direct and root causes determined and corrective action planned. Incidents may be analysed covering the following ways to prepare and implement an effective prevention plan:

(i) Body part injured

(ii) Age of the victims

(iii) Time of accidents

(iv) Causes of accidents

(v) Nature of injury.

For detailed guidelines on analysis of incidents and computation of injury rate refer IS 3786.

(m) The following reactive health and safety indicators should be used to measure and monitor the health and safety performance of the project site:

(i) Number of near miss cases

(ii) Number of first aid cases

(iii) Lost time injury frequency rate

(iv) Lost time injury severity rate.

(n) The health and safety performance of subcontractors shall be monitored on a regular basis and necessary directive and support shall be given to achieve the set health and safety objectives and targets.

(o) All accidents leading to property damage/personnel injuries/fatal accident/near miss and dangerous occurrence should be reported to the facility's engineer-in-charge immediately

(p) All 'near-miss' accidents should also be recorded/reported and investigated and recommendations arising out should be implemented on priority.

9.9 Training/Orientation

(a) It shall be ensured that all employees are competent to perform the assigned work safely on the basis of appropriate education, training or experience. The competency requirements of different categories of employees shall be mapped and procedures shall be implemented to ensure that those deployed meet the competence requirements.

(b) The objective of health and safety training shall be to equip the employee with necessary knowledge and skill to perform the work assigned to him in a safe manner, to foster continual improvement and to imbibe safety culture.

(c) Preferably, the training should be carried out away from the working place of the participants to ensure focused attention on the training for both trainer as well as trainees.

(d) After completion of training due procedure shall be followed for obtaining the feedback from the participants on the effectiveness of the training. Effectiveness of training imparted shall be monitored for continual improvement and necessary corrections in implementation.

(e) The training/orientation programme should be implemented to meet the mandatory requirements. [Rule 43(2) (m) of the Atomic Energy (Factories) Rules 1996]. The training should be phased as follows:

(f) Induction cum orientation training should include the overall safety aspects of the work and give a general overview of the various hazards, the particular activities and the do's and don'ts. As a part of training, workers should also be given demonstrations on use of personal protective equipment, first aid and fire-fighting equipment, fire mock drills, other emergency preparedness etc.

(g) The line manager along with the safety representative should conduct pre-job briefing on day-to-day basis prior to specific hazardous jobs. This will make the workers aware of the hazards and the precautions to be taken.

(h) Refresher training should be imparted to each worker at least once in a year.

(i) A training schedule should be prepared by the construction agency and communicated to facility for concurrence.

(j) Records of training, demonstration and pep talk should be maintained.

9.10 Permit to Work System

(a) Activities requiring permit to work shall be decided before starting the construction and shall be suitably documented in the project health and safety plan. Some of the activities which shall require permit to work are:

(i) Excavation

(ii) Entry into confined spaces

(iii) Electrical work (HV/LV)

(iv) Opening manholes, covers and grills

(v) Blasting operation

(vi) Hot work

(vii) Work on plant and machinery and other power driven equipment

(viii) Working at height

(ix) Working at night

(b) The contractor should establish a permit to work system for any other hazardous activity, which it feels necessary to be controlled administratively for safe execution.

(c) Contractor should obtain valid safety work permit before carrying out any hazardous job and shall maintain a copy of it with him through out the period of his work. Record of safety work permit should be maintained in a systematic manner. All the safety conditions and requirements stipulated in the safety work permit should be ensured strictly.

(d) Contractor should ensure that only authorized personnel are deployed for hazardous works/jobs (refer item 3.11 for hazardous job) and provide facilities for the same.

9.11 Job Hazard Analysis

(a) It should be ensured by contractor that a safe work procedure exists for all the hazardous jobs as mentioned hereunder and the requirements of the safety procedures are ensured at the work sites. Job hazard analysis (JHA) should form a part of such safe work procedures. A checklist based on JHA should be prepared. This checklist should be crosschecked by the line managers and verified by safety officer.

Typical list of jobs requiring job hazard analysis (This list is illustrative only and not exhaustive) is as follows:

(i) Excavation

(a) Blasting including under water blasting

(b) Earth and stone removal/backfilling/dumping of earth/ stones

(c) Any excavation more than 1.8 m depth.

(ii) Work at height (working beyond 3.5 meters above ground)

(a) Erection and dismantling of scaffolding, platforms, shuttering/de-shuttering work

(b) Dome work, rod bending, construction of chimney and cooling towers

(c) Working on tower crane.

(iii) Materials and material handling

(A) Critical equipment handling e.g.

(a) Calandria

(b) Steam generators

(c) Turbine generator components

(d) Diesel generator set

(e) Generator stator

(f) End shields

(g) Fuelling machines components

(h) Heat transport pumps etc.

(B) Hazardous chemical handling e.g.

(a) Acids and alkalis

(b) Ammonia

(c) Chlorine

(d) Freon

(e) Hydrazine

(f) Hydrogen sulphide

(g) LPG

(h) Morpholine

(C) Movement of heavy material by crane

(D) Movement of tractor trolley on slopes

(E) Manual lifting of heavy material to height

(F) Erection of heavy machinery, equipment.

(iv) Electrical connection

(a) Field connection for electrical installation

(b) Installation of lighting fixtures

(c) Charging of electrical system

(d) Charging of transformer, switch yard, switch gears

(e) Working near high voltage lines

(f) Use of portable electrical tools.

(v) Equipment/structural erection work

(a) Material handling

(b) Loading and unloading

(c) Transportation of material from one place to other

(d) Steel fabrication and erection

(e) Cleaning and maintenance of batching plant equipment.

(vi) Finishing/painting work

(a) Painting at height

(b) Painting in confined space.

(viii) Other specific work

(a) Work with pneumatic tools/compressed air

(b) Work on pressure vessels/lines

(c) Work in the vicinity of steam lines

(d) Work in high enthalpy area

(e) Work in high noise area

(f) Work in confined space including tunnels and trenches

(g) Work in isolated area (away from main site)

(h) Radiography work

(i) Work related to welding, gas cutting, grinding

(j) Working near conveyor, rotating machine

(k) Leak detection testing.

9.12 Reward

(a) To motivate the employees and organisation to work safely measures can be implemented based on the suitability. Selection and rewarding for the following categories may be considered on regular basis:

(i) Safest workmen

(ii) Safest supervisor

(iii) Safest area

(iv) Safest sub-contractor, etc.

(v) Sub-contractors and employees may be rewarded when the project achieves significant million man-hours without any lost time injury.

10. WORK SPECIFIC SAFETY MEASURES

10.1 General

(a) The contractor should ensure that safety precautions are taken during the execution of awarded work and work areas are maintained safe at all times. At the end of each shift and at all times when the work is suspended, it should be ensured that the work area is left safe in such a way that no materials and equipment that can cause damage to existing property, personal injury or interfere with the other works of the project or station are left in an unsafe manner.

(b) The contractor should ensure to provide and maintain all lights, guards, fencing, warning signs, caution boards and other safety measures and provide for vigilance as and when necessary for the protection of workers and for the safety of others. The caution boards should also have appropriate symbols.

(c) Adequate lighting facilities such as floodlights, hand lights and area lighting should be provided at the site of work, storage area of materials and equipment and temporary access roads within the working area.

(d) All works should be planned so as to avoid interference with other facilities, works of other contractors or sub-contractors at the site. In case of any interference, necessary coordination should be ensured for safe and smooth working.

(e) It should be ensured that the instructions given by the safety officer or his designated nominee regarding safety precautions, protective measures, housekeeping requirements, etc. are complied with. The safety officer with due intimation to line manager should have the right to stop the work, if in his opinion, proceeding with the work will lead to an unsafe and dangerous condition. Line manager should arrange to get the unsafe condition rectified and/or provide appropriate protective equipment.

(f) Contractor should ensure that each job with a hazard whether small or big is intimated to the Head, industrial safety of the facility well before it is taken up.

(g) The contractor should be fully responsible for non-compliance of any of the safety measures or requirements, implications, injuries, fatalities, dangerous occurrences and compensation arising out of such situations or incidents.

(h) Maximum duty hours of an individual should be as per the Factories Act 1948 or its latest amendment.

(i) Illumination levels should be as per the statutory requirements.

10.2 Rock Blasting

(a) All blasting operations should be carried out on the basis of procedures approved by Head, industrial safety and engineer-in-charge. All works in this connection should be carried out as per BIS specification/code (IS 4081: 1986. Title:- Safety code for blasting and related drilling operations (First Revision)). Barricades, warning signs etc. should be placed on the roads/open area.

(b) Blasting permit should be obtained from Head, Industrial Safety at least one day before the blasting operation and precautions mentioned there in shall be ensured by the engineer-in-charge before blasting operation.

(c) The blaster should have a licence from competent authority under Explosive Rules, 1983 for blasting work. It should also be ensured that he knows about the risks involved.

(d) Blasting should be done under the supervision of competent engineer/ supervisor.

(e) Blasting in the open site should only be carried out during fixed hours every day/fixed day in the week between sunrise and sunset. Residents of adjacent area should be informed in advance about the blasting schedule.

(f) No blasting should be undertaken during thunderstorm.

(g) Necessary precaution should be taken to ensure the stability/integrity/ safety of the adjacent structure by limiting the peak particle velocity.

(h) No loose material, such as tools, drilling equipment, etc. should be left on the surface to be blasted. Proper muffling arrangement of the blasting area should be ensured to avoid flying of blasted material.

(i) Authorized blaster should personally ensure that all the personnel/ equipment has been removed from the blasting area before the blasting operations.

(j) Blasting area should be free of detonating gas, inflammable objects, sparking or damaged wiring system, stray currents and static electricity.

(k) All electrical lines in blasting area should be de-energised.

(l) Entry of unauthorized personnel should be prevented by displaying warning signs.

(m) In case of misfire, no person should be allowed to approach the blasting site unless it is inspected and cleared by a competent engineer/supervisor.

(n) Explosives and blasting material should be stored only in clean, dry, well-ventilated, suitably constructed bullet/magazine which should be fire resistant and securely locked. Stock book should be kept accurate and maintained. Licence should be obtained for storage of explosive as per the Explosives Act, 1884.

(o) Blasting caps, electric blasting caps or primers and detonators should not be stored in the same box, container or room with other explosives.

(p) Precautions against lightening should be provided in accordance with Indian Electricity Rules, 1956 (amended in 2000).

(q) The explosives should be transported in specially designed vehicles bearing a special sign or inscription entitled 'DANGER-EXPLOSIVES'. Also detonators separated from other explosive should be transported in a separate compartment.

10.3 Excavation, Trenching and Earth Removal

(a) Before taking up excavation work, necessary permission should be obtained from the engineer-in-charge with reference to existing underground services.

(b) The Line manager of the works should exercise full care to ensure that no damage is caused by him or his workmen, during the operation/excavation etc., to the existing water supply, sewerages, power or telecommunication lines or any other services or works. He should provide and erect before construction, substantial barricades, guardrails, and warning signs around the work area. He should also furnish, place and maintain adequate warning lights, display board, signals etc., as required.

(c) All trenches 1.2 m or more in depth should at all times be supplied with at least one ladder for every 30 m along the trench. Ladders shall extend from bottom of the trench to at least 1 m above the surface of the ground.

(d) The sides of the trench/pit in soil, which are 1.2 m or more in depth should be stepped back to give suitable slope (angle of repose) or securely held by timber bracing or appropriate shoring/support, to avoid the danger of soil slides from collapsing. The excavated material should not be placed within 1.5 m or half of the depth of the pit whichever is more from edges of the trench/pit. Cutting should

be done from top to bottom. Under no circumstances mining or under-cutting should be done.

(e) Workers should not be exposed to the danger of being buried by excavated material or collapse of shoring. Measures to prevent dislodgment of loose or unstable earth, rock or other material from falling into the excavation by proper shoring shall be ensured.

(f) The stability and safety of the excavation, adjacent structures, services and other works should be ensured.

(g) All excavated area should be fenced off by suitable railing and installation of caution board to warn the persons from slipping or/ falling into the excavation pit/ mound.

(h) All excavated areas shall have an illumination level of at least 20 lux for night work and a red danger light shall be displayed at prominent place near the excavation site to warn approaching traffic and men.

(i) For removal of earth from an earth mound/excavated heap a written permission should be obtained from the engineer-in-charge of the work. As far as practical, earth should be removed mechanically. Wherever manual removal of earth is involved, earth should be removed from the top by maintaining a slope equal to the angle of re-pose of the earth. Such work should be constantly supervised to ensure that no under-cutting is done and to ensure that no person is trapped.

(j) Dumping of excavated soil should be done at a specified area under proper supervision with respect to signaling, illumination and safety clearance.

(k) It should be ensured that at a construction site of a building or other construction work, every vehicle or earth moving equipment is equipped with (a) silencers, (b) tail lights, (c) power and hand brakes, (d) reversing alarm (e) search light for forward and backward movement, which are required for the safe operation of such vehicle or earth moving equipment and (f) the cab of the vehicle or earth moving equipment is kept at least one meter from the adjacent face of a ground being excavated. (g) indicator etc.

(l) It should be ensured that when a crane or shovel is traveling, the boom of such crane or shovel is in the direction of such travel and the bucket or scoop attached to such crane or shovel is raised and without load, except when it is traveling downhill.

(m) Before loading or unloading power trucks or trailers attached to tractors, the brakes should be applied and if vehicle is on a sloping

ground, the wheels should be blocked. Handcart should not be used for the transfer of construction/erection materials in the construction area. However if the exigency demands urgent transfer of light materials a small handcart may be permitted with the prior approval of the Engineer-in-charge.

(n) It should be ensured that at a construction site of a building or other construction work:

(i) All transport or earth moving equipment and vehicles are inspected at least once in a week by responsible persons and in case any defect is noticed in such equipment or vehicle, it is immediately taken out of service.

(ii) Safe gangways are provided for to and fro movement of building workers engaged in loading and unloading of lorries, trucks, trailers and wagons.

(iii) All earth moving equipment, vehicles or other transport equipment be operated only by such persons who are adequately trained and possess such skills as required for safe operation of vehicles or other transport equipment.

(iv) Trucks and other equipment are not loaded beyond their safe carrying capacity, which should be clearly marked on such trucks and other equipment.

(v) No unauthorised person rides the transport equipment employed in such work.

(o) It should be ensured at a construction site of a building or other construction work that:

(i) A shovel or an excavator whether operated by steam or electric or by internal combustion used for such work is constructed, installed, operated, tested and examined as required under any law for the time being in force and the relevant national standards.

(ii) Buckets or grabs of power shovels are propped to restrict the movement of such bucket or grabs while being repaired or while the teeth of such bucket or grabs are being changed.

(p) It should be ensured at a construction site of a building or other construction work that:

(i) An operator of a bulldozer before leaving - applies the brakes, lowers the blade and ripper and puts the shift lever into neutral.

(ii) A bulldozer is parked on level ground at the close of the work.

(iii) The blade of a bulldozer is kept low when such bulldozer is moving uphill.

(iv) Bulldozer blades are not used as brakes except in an emergency.

(q) It should be ensured at a construction site of a building or other construction work that:

(i) A tractor and a scraper are joined safely at the time of its operation

(ii) The scraper bowls are propped while blades of such scraper are being replaced.

(iii) A scraper moving downhill is driven in low gear.

(r) It should be ensured at a construction site of a building or other construction work that:

(i) Before a road roller is used on the ground, such ground is examined for its bearing capacity and general safety, especially at the edges of slopes such as embankments on such grounds.

(ii) A roller is not moved down hill with the engine out of gear.

(s) Vehicle carrying excavated material should have proper cover over the driver's cabin.

10.4 Safe Means of Access/Platforms

(a) Adequate safe means of access and exit should be provided for all work places, at all elevations.

(b) Suitable scaffolds should be provided for workmen for all works that cannot be done safely from the ground, or from solid platform except such short duration work that can be done safely from ladders. Bamboo/wooden scaffolding should not be permitted.

(c) Where the platform for working is more than 3.5 m above ground, the width of the platform should be minimum 1 m.

(d) Ladder should be of rigid construction having sufficient strength for the intended loads. Wooden/bamboo/rope ladders should not be permitted. All ladders should be maintained in good condition. The ladders should be fixed to the ground or rigid platforms. An additional person should be engaged for holding the ladder, if ladder is not securely fixed. Ladder shall be extended from floor to at least one meter above the platform.

(e) A portable ladder should be given an inclination not steeper than 1 in 4 (1 horizontal and 4 vertical). Ladders should not be used for climbing while carrying materials in hands. While climbing both the hands should be free.

(f) Any working platform on scaffolding or staging more than 3.5 m above the ground or floor should have a guard rail attached, bolted, braced at least 1.0 m high above the floor or platform of such scaffolding or staging along with mid-rail.

(g) The planks used for any working platform should not project beyond the end supports to a distance exceeding four times the thickness of the planks used. The planks should be rigidly fixed at both ends to prevent sliding, slipping or tilting. The thickness of the planks should be adequate to take load of men and materials and should not collapse. Plywood or packing wood should not be used as planks.

(h) The guardrail should extend along the entire exposed length of the scaffolding with only such opening as may be necessary for the delivery of materials. Standard railing should have posts not more than 2 m apart and an intermediate rail halfway between the floor or platform of the scaffolding and the top rail. Such scaffolding or staging should be so fastened as to prevent it from swaying from the building or structure. Scaffolding and ladder should conform to IS 3696 (Part I): 1987 and (Part II): 1996.

(i) Working platforms of scaffolds should have toe boards at least 15 cm in height to prevent materials from falling down.

(j) A sketch of the scaffolding proposed to be used should be prepared and approval by the engineer-in-charge obtained prior to start of erection of scaffolding. All scaffolds should be examined by engineer-in-charge before use.

(k) Working platform, gangways and stairways should be so constructed that they should not sag unduly or unequally and if the height of the platform or gangway or stairway is more than 3.5 m above ground level or floor level, they should have adequate width for easy movement of persons and materials and should be suitably guarded.

(l) No single portable ladder should be used for access to a height of more than 4.5 m. For ladders up to 3m in length the width between styles (side bars)/width in the ladder should in no case be less than 300 mm. For longer ladders this width should be increased by at least 20 mm for each additional meter of length. Step/rungs spacing should be uniform and should not exceed 300 mm. Portable ladder should be used only for access to work place. In case work place is higher than 4.5 meters, pre-fabricated steel staircase should be used.

10.5 Work at Height

(a) Person to work at height should be medically fit and should have height pass issued by safety section. (Appendix-D Part A, B and C). Safety training should be imparted before working at height.

(b) Safety work-permit system for working at height should be obtained from industrial safety section.

(c) At elevated places, secure access and foothold should be provided. Adequate and safe means of access and exit should be provided at all work places for all elevations. Means of access may be portable or fixed ladder, ramp or a stairway. The use of crosses, braces or framework, as a means of access to the working platform should not be permitted.

(d) Linear movement at height should be reduced to minimum. In case of such movement provision for anchoring the safety belt should be made.

(e) Where barricades cannot be installed, a safety net of adequate strength should be installed close to the level at which there is a danger of fall of personnel/fall of objects.

(f) In case where 'work at height' is on asbestos roof, crawling board/ roof ladder should be used to walk across the asbestos roof.

10.6 Electrical Safety

(a) All electrical installations shall comply with the appropriate statutory requirements given below and shall be subject to approval of the Electrical Engineer and Safety Officer.

(i) The Electricity Act, 2003

(ii) The Indian Electricity Rules 1956 (as amended in 2000)

(iii) The National Electricity Code 2008

(iv) Atomic Energy (Factories) Rules, 1996

(v) Other relevant rules of Statutory Bodies and power supply authority

(vi) Relevant standards of BIS

In addition to the above statutory provisions, the clauses indicated in this document shall also be complied.

(b) It shall be the responsibility of the user seeking temporary power supply to indicate in writing, if any of the clauses (requirements

noted in above regulations and in this document) are conflicting with each other and for which the user cannot decide the course of action regarding safe installation, commissioning, operation, maintenance and decommissioning of the electrical installations.

(c) The electrical engineer and safety officer of the agency providing temporary power supply shall interpret the concerned conflicting clauses and approve in writing the safe course of action.

(d) The application Form-1 (Form-1A, 1B and 1C) as mentioned in Appendix-E should be submitted by the user for getting the temporary power supply.

(e) After installation of temporary electrical panels, wiring works by the user, Certificates as per Form-1D (Appendix-E) should be submitted to the provider.

(f) Certificate of safety officer and authorization of electrical engineer for energisation of temporary power supply should be filled as per Form-1E (Appendix-E).

10.7 Material Handling and Lifting Machines and Tackles

(a) It should be made compulsory to supervise jobs like lifting/placing/ loading/unloading/carrying/transporting etc. of heavy material by qualified supervisor having knowledge about hazards involved and precautions to be taken for such job.

(b) The line managers should ensure that the material handling equipment used is adequate to handle the load.

(c) Manual pulling of heavy equipment and trolley loaded with heavy material is not to be permitted.

(d) Stacking and handling of heavy materials should be done on a firm ground to prevent settlement.

(e) No lifting machine and no chain, rope or lifting tackle, except a fiber rope or fiber rope sling, shall be taken into use for the first time in that factory unless it has been tested and all parts have been thoroughly examined by a competent person. A certificate of such a test and examination specifying the safe working load or loads and signed by the person making the test and the examination has been obtained and is kept available for inspection.

(f) Use of lifting machines and tackles should conform to relevant BIS requirements [IS 13367 (Part 1): 1992 Reaffirmed 2003, IS 4573: 1982 (Reaffirmed 2000) and IS 13834 (Part 1): 1994 Reaffirmed 2003 etc. The accessories and the attachments, anchorages and

supports etc. should be ensured in healthy conditions by regular inspections at defined frequencies.

(g) Every rope used in hoisting or lowering materials or as a means of suspension should be of good quality and adequate strength and free from any defect. This should be ensured by regular inspection as per IS 2762: 1982- Specification for wire rope slings and sling legs (first revision).

(h) Every crane operator or lifting appliance operator should be authorized. No person under the age of 18 years should be in charge of any hoisting machine or give signal to an operator of such machine.

(i) In case of every lifting machine (and of every chain, ring, hook, shackle, swivel and pulley block used in hoisting or as a means of suspension) the safe working load should be ascertained and clearly marked. In case of a lifting machine having a variable safe working load, each safe working load and the conditions under which it is applicable should be clearly indicated. No part of any machine should be loaded beyond the safe working load except for the purpose of testing. This should be approved by the engineer-in-charge and Head, Industrial Safety.

(j) In case of facilities machines, the safety of the machines shall be ensured by the Engineer-in-charge. As regards the Contractor's machines, the contractor should declare the safety of the machine to the Engineer-in-charge whenever he brings any machinery to site of work and get it verified by the engineer-in-charge, supported by a valid test certificate by the competent person.

(k) Thorough inspection and load testing of lifting machines and tackles should be done in the presence of competent person at least once in every 12 months and records of such inspections and testing should be maintained.

(l) No mobile crane should be allowed to move under live high-tension power transmission line.

(m) While lifting loads, cranes should be located on level ground.

(n) A thorough load analysis should be carried out before using cranes in tandem.

(o) Motors, gear transmission, couplings, belts, chain drives and other moving parts of hoisting appliances should be provided with adequate safeguards. Hoisting appliances should be provided with such means, which will reduce the risk of any part of a suspended load becoming accidentally displaced or lowered.

(p) It should be ensured that the cabin of the lifting machine in outdoor service:

(i) is made of fire resistant material,

(ii) has a suitable seat, a footrest and protection from vibration,

(iii) affords the operator an adequate view of the area of operation,

(iv) affords the operator adequate protection against the weather, and

(v) is provided with fire extinguisher.

10.8 Welding and Gas Cutting

(a) Welding and gas cutting operations should be done by qualified and authorized persons only.

(b) Safety work permit shall be obtained (wherever necessary like presence of flammable or combustible material etc.) before flame cutting/welding is taken up.

(c) Welding and gas cutting should not be carried out in places where flammable or combustible materials are kept and where there is danger of explosion due to presence of gaseous mixtures. In case the requirement cannot be avoided, specific approval and procedure should be ensured and adequate precautions should be taken.

(d) Welding and gas cutting equipment including hoses and cables should be maintained in good condition.

(e) Barriers should be erected to protect other persons from harmful rays from the work. When welding or gas cutting is done in elevated positions, precautions should be taken to prevent sparks or hot metal falling below on persons or combustible materials.

(f) Suitable type of protective clothing consisting of fire resistant gauntlet gloves, leggings, boots and aprons should be provided to workers as protection from heat and hot metal splashes. Face shields with filter glasses of appropriate shade should be worn.

(g) Adequate ventilation should be provided while welding, brazing and cutting the metals like zinc, brass, bronze, galvanised or lead coated material.

(h) Welding and gas cutting on drums, barrels, tanks or other containers should be taken up only after ascertaining that they have been emptied, cleaned thoroughly and made free of flammable material.

(i) Fire safety measures should be available as required near the location of welding/cutting operations.

(j) Flash back arrestor should be provided with gas cutting and gas welding sets.

(k) For electric (Arc) welding the following additional safety precautions should be taken:

(i) When electrical welding is undertaken the return lead of welding machine should be directly connected to the job invariably.

(ii) Provision must be in place in electric welding machine to prevent physical contact with live parts.

(iii) The welding cables and power cables should be routed separately to avoid entanglement.

(iv) The electric welding set should have suitable earth connections. There should be an electrical isolation device in the input power supply side on the welding machine.

(l) Double gauges should be used for all gas cylinders used for cutting/ welding. Pressure gauges/regulators should be in healthy condition.

10.9 Rotary Cutters/Grinders

(a) All portable cutter/grinders should be provided with the wheel guard in position.

(b) Grinding wheels of specified diameter only should be used on all grinders in order to limit the prescribed peripheral speed.

(c) In pedestal grinder, the gap between tool rest and grinding wheel should be maintained less than 3 mm.

(d) Goggle/face shield should be used during grinding operation.

(e) No grinding wheel should be used after its expiry date.

(f) Ear muff/ear plug should be used during the welding /cutting jobs.

(g) Portable appliances, which are powered by single phase AC supply, shall be provided with three-core cable and three pin plug, otherwise the whole body should be double insulated.

(h) Safety work permit should be obtained (wherever necessary like presence of flammable or combustible material etc.) before grinding is taken up.

(i) Fire safety measures should be available as required near the location of grinding operations.

10.10 Concrete Mixing Equipment

(a) Cement bags should be stacked on wooden planks in dry and leak proof area, 150 mm to 200 mm from the floor and 450 mm away from walls. Height of the stack should not be more than 15 bags or 1.5 meters which ever is lower. Width of the stack should not be more than 4 bags or 3 meters. Lateral loading of the walls of the storage room by stacking should not be permitted. Stacking of the bags should not be used as a working platform.

(b) Shuttering and supporting structures should be of adequate strength and approved by engineer-in-charge. This should be ensured before concrete is poured.

(c) If the mixer has a charging skip the operator should ensure that the workmen are out of danger before the skip is lowered.

(d) Adequate walking platforms are to be provided in the reinforcement area to ensure safe walking for pouring concrete on the roof.

(e) When workmen are working/cleaning the inside of the drum of mixer, the power of the mixer should be switched off and 'Do not operate' tag should be provided. The plant operation and cleaning of mixing pan should be carried out as per equipment supplier's instructions.

(f) Interlocks between the cover and the mixer rotor shall be established to ensure that the agitator does not start when the cover is in open condition.

(g) It should be ensured that moving parts of the elevators, hoists, screens, bunkers, chutes and grouting equipment used for concrete work and of other equipment used for storing and transporting of ingredients of concrete are securely fenced to avoid contact of workers with such moving parts.

(h) It should be ensured that screw conveyors used for cement, lime and other dusty material are completely enclosed.

(i) Workers engaged for handling bulk cement in a confined place should be provided with tight fitting goggle, approved respirators and protective clothing, which will fit snugly around the neck, wrist and ankles.

(j) The following should be ensured for every pipe carrying pumped concrete:

  (i) The scaffolding carrying a pipe for pumped concrete should be strong enough to support such pipe at a time when such pipe is filled with concrete or water or any other liquid and to bear safely all the building workers who may be on such scaffold at such time.

(ii) Securely anchored at its end point and each curve on it.

(iii) Provided with an air release valve near the top of such pipe; and securely attached to a pump nozzle by a bolted collar or other adequate means.

(k) The following should be ensured while using the electric vibrators in concreting work at a construction site of a building or other construction work such that:

(i) Such vibrators are earthed.

(ii) The leads of such vibrators are heavily insulated.

(iii) The current is switched off when such vibrators are not in use.

10.11 Painting

(a) Appropriate breathing air respirators should be provided for use by the workers when paint is applied in the form of spray, or a surface having lead paint is dry rubbed or scraped.

(b) Only the quantity of paint, thinner and polish required for the day's work should be kept at the work spot. Excess storage should not be permitted at the work spot.

(c) Smoking, open flames or sources of ignition should not be allowed in places where paints, varnish, thinner and other flammable substances are stored, mixed or used. A caution board, with the instructions written in national language and regional language, 'SMOKING - STRICTLY PROHIBITED' should be displayed in the vicinity where painting is in progress or where paints are stored. Symbols should also be used on caution boards.

(d) All electrical equipment of paint storage room should be of explosion proof design. Suitable fire extinguishers / sand buckets should be kept available at places where flammable paints are stored, handled or used.

(e) When painting work/hot resin mix is done in a closed room or in a confined space, adequate ventilation should be provided and ensured. In addition, suitable respirators should be provided. No portable electric light or any other electric appliance of voltage exceeding 24 volts should be permitted for use inside any confined space. Walkie-talkie or other means of communication should be provided. Rescue arrangement like full body harness with lifeline, tripod with pulley and extra BA sets should be available.

(f) The workers should use PVC gloves and/or suitable barrier creams to prevent the skin contact with Epoxy resins and their formulations used for painting.

10.12 Demolition

(a) Before any demolition work is commenced and also during the progress of the work, all roads and open area adjacent to the work site should either be closed or suitably cordoned. Appropriate warning signs should be displayed for cautioning approaching persons/ vehicles.

(b) Before demolition operations begin, it should be ensured that all the service lines are de-energized.

(c) Persons handling demolition operations shall use appropriate PPE.

(d) All demolition operations should be carried out with safe and duly approved procedures which shall include following but not limited to:

(i) No masonry/material should be permitted to fall in such masses or volume or weight so as to endanger the structural stability of any floor or structural support.

(ii) No wall, chimney or other structure or part of a structure is left unguarded in such a condition that it may fall, collapse or weaken due to wind pressure or vibration.

(iii) No floor roof or other part of the building should be overloaded with debris or materials as to render it unsafe.

(e) After the demolition, the debris and other materials collected should be disposed safely and not permitted to be dropped freely.

(f) Entries to the demolition area shall be restricted to authorized persons wearing safety helmets and safety shoes.

10.13 Traffic

(a) All the vehicles moving at sites should conform and comply with the requirements of Motor Vehicles Act, 1988 and the Rules made thereunder. All the drivers /operators of vehicles should possess valid driving license as per Motor Vehicles Act, 1988 or its latest amendment.

(b) When the construction work causes interference with traffic such as road cutting or transit unloading of heavy equipment etc. notice of such interference should be given to the engineer-in-charge and Head, industrial safety well in advance with the details of start of the work and time required.

(c) A cleaner/assistant must be available for all heavy vehicles whenever vehicles move forward as well as in the reverse direction. All vehicles should be fitted with proper reverse horns, back view mirrors and indicator signals.

(d) Facility shall ensure that the assessment of the driver's visual ability is carried out as per Rule 55 of the Atomic Energy (Factories) Rules, 1996/guidelines of advisory committee on occupational health (ACOH), AERB or as per the latest amendments in statutes.

(e) Effective speed breakers with yellow stripes on the roads to regulate the speed at the vulnerable points should be installed. Effective barricading with adequate caution signs should be placed to warn the vehicle drivers whenever the jobs are carried out on the road.

(f) All vehicles moving at the site should have roadworthiness certificate issued by the concerned authority.

(g) Special limit boards and caution boards indicating turns should be installed wherever necessary.

(h) In general, the following maximum speed limits should be specified and implemented. Vehicles speed limits should be as per Motor Vehicle Act or 20 Km/h. Extra precautions and care should be exercised particularly during heavy material/equipment movements.

(i) Safety awareness programmes should be conducted for all the drivers of the light, medium and heavy vehicles.

10.14 Work in Radiation Area

The facility shall follow the stipulations under Atomic Energy (Radiation Protection) Rules, 2004 and AERB Safety Manual on 'Radiation Protection for Nuclear Facilities'[AERB/NF/SM/O-2 (Rev.4)] with regard to work in the radiation area and other works related with radiography, etc.

10.15 Work in and Around Water Bodies

(a) When work is done at a place where there is risk of drowning, all necessary rescue equipment such as life buoys and life jackets should be provided and kept ready for use.

(b) All necessary steps shall be taken for prompt rescue of any person in danger and adequate provision should be made for prompt first-aid treatment of all injuries likely to be sustained during the course of the work. Proper record of entry/exit to and from water bodies shall be maintained on shift basis and search operation shall be conducted as soon as any person is detected to be missing.

(c) Caisson Work

(i) Safe means of access should be provided to the place of work in the caisson and adequate means should be provided to safely reach the top of caisson in the event of inrush of water.

(ii) The work relating to construction, positioning, modification or dismantling of caisson shall be done under the supervision of a responsible person.

10.16 Fire Safety

(a) Provisions prescribed in the AERB safety standard on 'Fire Protection Systems for Nuclear Facilities', [AERB/NF/SS/FPS (Rev. 1)] shall be complied.

(b) All necessary precautions should be taken to prevent outbreak of fires at the construction site. It should be ensured that all hot works are carried out under valid work permit.

(c) Combustible materials such as wood, cotton waste, oil, coal, paints, chemicals etc., should be segregated and kept to the required bare minimum quantity at work place.

(d) Containers of paints, thinners and allied materials should be stored in a separate room which should be well ventilated and free from excessive heat, sparks, flame or direct rays of the sun. The containers of paint should be kept covered or properly fitted with lid and should not be kept open except while using.

(e) Adequate number of trained persons from approved fire training centre required to extend fire safety coverage should be ensured.

(f) Fire extinguishers as approved by the engineer-in-charge/in-charge of fire station/safety in-charge should be located at the construction site at appropriate places.

(g) Adequate number of trained workmen in fire fighting who can operate fire extinguishers should be ensured.

(h) Portable fire extinguishers with periodic inspection, maintenance and re-filling complying with the mandatory requirements should be ensured.

(i) Availability of adequate water for fire fighting should be ensured.

(j) Implementation of the provisions of various statutory licenses for storing gas cylinders, petroleum products, explosives etc. as per the relevant Acts and Rules should be ensured wherever required.

10.17 Environmental Safety

Relevant provisions of the state/central statutory authority regarding environment protection should be adhered to.

10.18 Public Protection

The Contractor should make necessary provisions to protect the public. He should be bound to bear the expenses in defense of every action or other proceedings at law that may be brought by any person for injury sustained owing to neglect of any precaution required to be taken to protect the public. He should pay for the any such damage and cost which may be awarded in any such suit, action or proceedings to any such person, or the amount, which may be fixed as a compromise by any such person.

10.19 Safety of Visitors

(a) Visitors for the project shall be given health and safety induction before they are allowed in to the construction project. It shall include the minimum PPE to be used, hazards and risks at the work area, restricted areas of entry, emergency response arrangements, etc.

(b) Visitors shall always be accompanied by one of the employees of the project site.

(c) Visitors shall not be allowed in the hazardous areas unless they are competent and trained to work in such areas.

10.20 Housekeeping

(a) It should be recognized that a proper place for everything and everything in its place is maintained for a good housekeeping.

(b) The material required for immediate use only should be brought to the designated workplace and stacked properly and labeled suitably.

(c) All work spots, site office and surroundings should all times be kept clean and free from debris, scrap, concrete muck, surplus materials and unwanted tools and equipment. A day-to-day collection and disposal of scraps/debris should be done safely at designated place.

(d) Electrical cables should be so routed as to allow safe traffic by all concerned. Cable should be preferably supported on the brackets fixed along the wall to maintain safe access. Wherever routing on the floor cannot be avoided, care should be taken to ensure mechanical protection of these cables and safe access is not disturbed.

(e) No material at any work place should be so stacked or placed or disposed off as to cause danger, inconvenience or damage to any person or environment.

(f) All unused scaffoldings, surplus/scrap materials and equipment/ systems like temporary electrical panels etc. should not be allowed to accumulate and shall be removed from the premises at the earliest.

(g) Accumulation of water /oil spillages on the floor or any other workplace should be avoided.

(h) Proper aisle space marking should be provided in all workplaces.

10.21 Other Statutory Provisions

Notwithstanding the clauses in the above subsections, there is nothing in these clauses to exempt the contractor from the provisions of any other Act or Rules in force in the Republic of India. In particular, all operations involving the transport, handling, storage and use of explosives should be as per the standing instructions and conform to the Indian Explosives Act, 1884 and the Explosives Rules, 1983. Handling, transport, storage and use of compressed gas cylinders and pressure vessels should conform to the Gas Cylinder Rules 2004 and Static and Mobile Pressure Vessels (Unfired) Rules 1981. In addition, The Indian Electricity Act 2003 and Indian Electricity Rules 2005, the Atomic Energy Act, 1962, the Radiation Protection Rules, 2004, the Atomic Energy (Factories) Rules, 1996 and AERB safety manual on 'Radiation Protection for Nuclear Facilities' [AERB/NF/SM/O-2 (Rev.4)] should be complied with.

11. PERSONAL PROTECTIVE EQUIPMENT

11.1 General

Although the primary approach in any safety effort is that the hazard to the workmen should be eliminated or controlled by engineering methods rather than protecting the workman through use of personal protective equipment (PPE). Engineering methods could include design change, substitution, ventilation, mechanical handling, atomization etc. Under those situations when it is not possible to introduce any effective engineering methods for controlling hazards, it is necessary that workman use appropriate type of PPE. For example, in construction work there is the possibility of a hand tool, a bolt, or some loose material to fall from an elevated level and striking the head of workman working below. It is therefore necessary that construction worker wear a safety helmet. It is for such situations, both the Factories Act 1948 and the Atomic Energy (Factories) Rules, 1996 have provisions for use of appropriate type of PPE.

It is thus recognized that use of PPE is an important and necessary consideration in the development of a safety programme. Once the safety professional decides that PPE is to be used by workmen, it is essential to select right type of PPE and construction agency should ensure that workman uses it and also PPE is correctly maintained.

11.2 Personal Protective Equipment (PPE)

(a) All personal protective equipment as considered necessary should be made available for the use of the persons employed on the site and maintained in a condition suitable for immediate use. Also adequate steps should be taken by line manager to ensure proper use of PPE.

(b) All the PPEs in use should be as per relevant IS standards as referred in the AERB safety guidelines on 'Personal Protective Equipment' (AERB/SG/IS-3).

(c) All persons employed at the construction site should use safety helmets. Safety helmet should be with BIS mark and should have its headband with back support and chin strap.

(d) Workers employed on mixing asphaltic materials, cement and lime mortars should use protective goggles, protective foot wears, hand gloves and respirators as required.

(e) Persons engaged in welding and gas-cutting works should use suitable welding face shields. The persons who assist the welders should use suitable goggles. Protective goggles should be worn while chipping and grinding.

(f) Stonebreakers should use protective goggles. They should be seated at sufficiently safe distances from one another.

(g) Safety goggles should be of shatterproof type and with zero power.

(h) Persons engaged in or assisting in shot blasting operations and cleaning the blasting chamber should use suitable gauntlets, overalls, shatterproof and dust-proof goggles and self contained breathing apparatus set.

(i) All persons working at heights more than 3.5 m above ground or floor and exposed to risk of falling down should use full body harness safety belts, unless otherwise protected by cages, guard railings, etc. In places where the use of safety belts is not feasible, suitable net of adequate strength fastened to substantial supports should be used.

(j) When workers are employed in sewers and inside manholes that are in use, it should be ensured that the manholes are opened and are adequately ventilated at least for an hour. After it has been well ventilated, the atmosphere inside the space should be checked for the presence of any toxic gas or oxygen deficiency by a competent person and recorded in the register before the workers are allowed to get into the manholes. A pilot team should enter the area donning self contained breathing apparatus (SCBA). The manholes opened should be cordoned off with suitable railing and provided with warning signals or caution boards to prevent accidents. There should be proper illumination in the night. Depending upon the work situation, the contractor should provide PPE including the SCBA as recommended by Head, industrial safety.

12. MEDICAL MANAGEMENT

12.1 General

(a) The contractor shall make arrangements for the first aid and medical services for the injured or ill persons for prompt attention or aid.

(b) The arrangement can be made by the contractor or an agreement can be in vogue with the facility.

(c) The medical facilities at first-aid centre shall be adequate to immediately cater to the injured based on the hazard potential and probable severe injuries.

(d) The first-aid centre shall be provided with the adequate equipment and medicines for catering to the site requirements. The first-aid centre shall be manned depending on the working hours / on round the clock shift basis. The services of at least one qualified medical practitioner (medical officer) shall be made available by the contractor.

12.2 Medical Facilities

(a) Medical facilities conforming to the provisions of the Atomic Energy (Factories) Rules, 1996 should be provided at all work sites.

(b) The requisite medical facilities in the form of a well-equipped first aid centre manned by qualified nursing personnel should be provided at all work sites. Contractor may avail this facility as per terms and conditions of the contract.

(c) In addition, well-maintained first-aid boxes should be kept at each location of the work by the contractor and availability of the personnel trained in first aid should be ensured.

(d) A manned and equipped ambulance should be available at work site during the working hours/on round-the-clock shift basis.

(e) It should be ensured by the facility that occupational health monitoring of contract workers is carried out as per provisions of the Factories Act 1948 as per the latest amendment and the stipulations/directives given by Atomic Energy Regulatory Board from time to time.

(f) Display of emergency contact numbers of important persons and hospitals and route map of site shall be maintained at designated places.

12.3 Medical Management of Serious Injuries

(a) In case of serious injuries, the injured should be shifted to the nearest first-aid centre at site immediately. The opinion of medical officer/ certifying surgeon should be sought immediately for medical management.

(b) After providing the first aid treatment the injured should be shifted to designated medical facility of the site/hospital for further medical assistance, in an ambulance along with a nursing attendant.

(c) The doctor at the medical facility of the site/hospital attending the case shall assess the extent of injuries and render immediate medical aid. If the situation warrants trauma/special care the injured shall be shifted to the referral hospital, having all the requisite facilities for specialized treatment in ambulance along with a medical attendant.

(d) A list of such referral hospitals for specialised medical management facilities for the injured persons should be available with the project management/Head, industrial safety and Head, medical services of the site for ready reference.

APPENDIX-D

APPLICATION FOR HEIGHT PASS

PART- A

Group/Section: _____

Agency: _____

1. Applicant's name : _____
2. Facility address : _____
3. Residential address : _____
4. Age : _____
5. Sex : _____
6. Height : _____
7. Gate Pass No. : _____
8. Name of contractor/agency with whom engaged at present : _____
9. Height pass required for work at _____ m. Height
10. Description of present job : _____
11. Previous experience of working at height : _____

S.No.	Name of the employer	Duration of employment	Work experience
1.			
2.			

12. Does the applicant suffer from any of the following ailments ? (If yes details to be given):

    (a) Blood pressure _____ (b) Epilepsy _____

    (c) Flat foot _____

    (d) Frequent headache or reeling sensation _____

    (e) Mental depression _____ (f) Limping gait _____

    (g) Aerofobia _____

Declaration:

I hereby declare that the above information furnished by me is true and correct. I shall always wear the safety belt and tie the life-line whenever working at unguarded heights of 3 m and above. I shall not misuse the height pass issued to me or transfer it to any other person. I shall never come to duty or work at height/depth under the influence of alcohol/drugs.

Date: Name:

Sign:

(Applicants Name and Signature or loss time injury (L.T.I) in case he cannot sign. In case of LTI an authorised person shall explain each point/item to the individual and certify on that behalf below the LTI)

I certify that I am satisfied with the above certification of the individual for the application of height pass and request for issue of height pass to him.

Name :

Sign:
(Agency Concerned)

Countersigned by:

Section Head (Facility)

PART-B

MEDICAL FITNESS CERTIFICATE

Certified that I, Dr. _____ have examined Shri._____ _____ aged _____ on (date) _____ who has signed below in my presence. General and physical examinations of Shri._____ do not reveal any abnormality. He does not suffer from any acute/chronic skin disease or any contagious or infectious disease. His eye sight is normal with/without glasses. In my opinion, Shri._____ is physically and mentally fit for working at height.

Details of examinations are given below:

Personal attributes:			**Medical aspects:**		
1.	Height	: _____	1.	Urine	: _____
2.	Chest	: _____	2.	Blood pressure	: _____
3.	Weight	: _____	3.	Epilepsy	: _____
4.	Hearing	: _____	4.	Flat foot	: _____
5.	Sight	: _____	5.	Frequent headache or reeling sensation:	_____
6.	Skin	: _____	6.	Mental depression:	_____
7.	Heart beating:	_____	7.	Limping gait	: _____
			8.	Aerophobia	: _____

Name:

Signature of workman

Signature and Rubber Stamp of Medical Practitioner with Reg. No.

PART-C

INDUSTRIAL SAFETY SECTION

(Considering the above medical certificate, the applicant has appeared on the following practical tests conducted by industrial safety section and the results are given below (strike off whichever is in-applicable)

(a) Wearing a safety belt and tying the rope knot : Pass/fail

(b) Walking over a horizontal structure at 3 m. height wearing a safety belt : Pass/fail

(c) General physique (OK/Not OK)

The above applicant's performance in the above tests has been satisfactory/ unsatisfactory due to the following.

So I certify and issue this height pass to Shri. _____ with Registration No. _____ in the height pass register. This is valid for one year from the date of issue i.e. up to .....

Date:

Name:

Signature

Scientific Assistant (Safety)

Safety Officer

APPENDIX-E

FORM - 1

APPLICATION FOR TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION

[Prescribed under clause 10.6(d)]

1.	Name and address of user.	
2.	Reference of tender or work order (if applicable)	:
3.	Name and designation of tender/work order issuing authority.	:
4.	Power supply application number†	:
5.	Name and designation of tender/work order/work supervising authority (engineer-in-charge).	:
6.	Expected date of commencement of temporary supply	:
7.	Expected date of decommissioning of temporary supply	:
8.	Voltage level (LV/MV/HV)	
9.	Type of connection (1Ph/3Ph)	
10.	Connected load (Kw)	
11.	Maximum demand(KVA)/Power factor	
12.	Single line diagram* of proposed power distribution scheme along with equipment data sheet (downstream installation after point of connection).	Enclosed (Form-1A)/Not enclosed
13.	Name of overall supervisor and available qualified Staff	Enclosed (Form-1B)/Not enclosed
14.	Auxiliary equipment data sheet (meters, fire extinguisher, first aid box etc)	Enclosed (Form-1C/Not enclosed
15.	Name and designation of provider's representative to whom the application is addressed.	:
16.	Name and designation of authorised signatory of user, who had submitted this application	:

† Power supply application number shall be different for same user with multiple applications for temporary supply

* All the drawings and tables shall be signed by user's representative indicated against 16 above.

Signature of authorised signatory of user

Signed endorsement of work order supervising authority indicated against 5 above.

FORM - 1A

EQUIPMENT DATA SHEET FOR OBTAINING TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION

(Prescribed against item-12 of form-1)

Name and address of user:

Power supply application Number:

Amendment No:

References:- Single line diagram (SLD) of the power distribution scheme with all equipment details (attach the SLD)

1. Identity	2. Type	3. Make and model	4. Manufacturer's S.No	5. Fixed/ Portable	6. Size	7. Last used date	8. Last test date	9. Latest test data	10. Rating

Signature of authorised signatory of user

Explanation of column headers:

1. Identity:- Identification mark/number/tag of equipment in single line drawing and layout drawing. Every equipment in single line drawing and layout drawing shall have suitable identification mark/number/tag.
2. Type:- Cable/CB/MCB/MCCB/ELCB/transformer/lightning arrestor/earthing station/ earthing connection/motor/lighting fixture/switch/fuse/switch, socket box etc.
3. Make and model:- manufacturer's name and corresponding model no.
4. Manufacturer's S. No:- serial number and date in name plate if available. Else NA
5. Fixed/portable:- Equipment is installed/laid/anchored to surface or portable.
6. Size:- depending upon type of equipment and as desired by provider representative e.g. length for cables or all dimensions if heavy equipment like transformer.
7. Last used date. date of last use else NEW
8. Last test date. latest test date by user or by manufacturer if NEW
9. Latest test data:- IR, HV, resistance, functional test data depending upon the type of equipment as desired by provider's representative.
10. Rating:- name plate rating of equipment like voltage, current, power (apparent, active, reactive), IP of enclosure, size (cable cross section) etc. depending upon the type of equipment and as desired by provider's representative.

FORM - 1B

STAFF DATA SHEET FOR OBTAINING TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION
(Prescribed against item-13 of form-1)

Name and address of user:

Power supply application Number:
Amendment No:-

1. Name	2. Address	3. Tel.No.	4. Responsibility	5. Certification detail	6. Resucitation training	7. Expe-rience	8. Other relevant training	9. Signature

Signature of authorised signatory of user

Explanation of column headers:

1. Name:- Name of agency/person
2. Address:-
3. Tel No:- regular, alternate and emergency telephone numbers
4. Responsibility:- whether responsible for installation, operation, maintenance, overall supervision etc. overall supervisor shall be indicated specifically.
5. Certification detail:- (a) type of certification e.g wire man license, electrical supervisor license, electrical contractor license, diploma in electrical engineering, degree in electrical engineering etc. (b) certifying agency e.g. state PWD, central PWD, CEA, name of college/university etc. (c) certificate/license number with date. (d) valid up to date or next renewal date must for contractor/supervisor license.
6. Artificial resuscitation training:- indicate YES/NO if the staff is trained to apply artificial resuscitation technique.
7. Experience.:- number of years of experience.
8. Other relevant training :- any other training in electrical/ safety course. Indicate name of training, duration (days/months), training providing agency.
9. Signature:- original signature of individual.

FORM - 1C

AUXILIARY EQUIPMENT DATA SHEET FOR OBTAINING TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION
(Prescribed against item-14 of form-1)

Name and address of user:

Power supply application Number:
Amendment No:-

Reference:- Layout drawing No. / _____

1. Identity	2. Type	3. Make and model	4. Manufacturer's S. No	5. Fixed/ Portable	6. Size	7. Last used date

Signature of user's representative

Explanation of column headers:

1. Identity:- identification mark/number/tag of equipment in layout drawing.
2. Type:- earthing rod/megger/multi meter/earth resistance meter/fire extinguisher/s and bucket/first aid box/resuscitation chart/rubber mat etc.
3. Make and model:- manufacturer's name and corresponding model no.
4. Manufacturer's S. No:- serial number and date in name plate if available. Else NA
5. Fixed/portable:- equipment is installed/laid/anchored to surface or portable.
6. Size:- depending upon type of equipment and as desired by provider representative.
7. Last used date. NEW for new equipment. NA for passive devices like chart/mat etc.

FORM -1D

(Prescribed under clause 4.6(e)]

Name of user agency **Power supply application number:-**

CERTIFICATE BY THE LICENSED ELECTRICAL CONTRACTOR

Certified that subject installations have been carried out by us or checked by us and is in accordance with I.E. Rules. The documents submitted with subject temporary power supply application (Form-1) is verified by us and the complete installation confirms to these documents.

We shall periodically inspect/check the installation so that no unsafe situation arises during use of this temporary power supply system. We understand that for the entire duration of existence of this temporary power supply system we shall be responsible for any unsafe installation, operation, maintenance, testing of the same which results into any loss of life or material. We shall immediately report to the provider's representative and ensure de-energisation of supply if any unsafe situation arises during use of this temporary power supply system.

Signature of the authorised signatory of licensed electrical contractor

Rubber seal of licensed electrical contractor

Date

CERTIFICATE BY THE USER

Certified that my/our installations have been carried out in accordance with the I.E. Rules and that I/We have employed competent agency/staff to handle the installations which is strictly as per the staff data sheet submitted in Form-1B.

We understand that for the entire duration of existence of this temporary power supply system we shall be responsible for any unsafe installation, operation, maintenance, testing of the same which results into any loss of life or material. We shall immediately report to the provider's representative and ensure de-energisation of supply if any unsafe situation arises during use of this temporary power supply system.

Signature of the authorised signatory of user

Name of signatory

Date

FORM -1E

[Prescribed under clause 10.6(f)]

CERTIFICATE BY THE SAFETY OFFICER

Certified that I have inspected the electrical installation referred here in after satisfying myself about the safe condition of the installation, I hereby recommend that the service connection be given to the contractor.

Signature of the safety officer

Name:

Date:

AUTHORISATION BY THE ELECTRICAL ENGINEER

The subject power supply application along with completed installation, necessary certificates (as per Form-1 of Appendix-E) is scrutinised by us. The proposal found to be in order and the installation can be energised on _____ in presence of your designated overall supervisor as indicated in Form-1B. Enclosed herewith the test report data sheet Form-1F. You are requested to carry out the periodic testing of equipment and submit the test report periodically as per this form.

Signature of the electrical engineer
of provider

Name of signatory

Date

FORM - 1F

TEST/MAINTENANCE REPORT DATA SHEET OF EQUIPMENTS OF TEMPORARY POWER SUPPLY SYSTEM AT WORK SITE DURING CONSTRUCTION
(Prescribed against form-1E)

Name and address of user:

Power supply application Number:
Amendment No:-

1. Identity	2. Type	3. Last tested date	4. Next due date of any test	5 Frequency of IR test	6 Frequency of HV test	7. Frequency of earth resistance test	8. Other tests

Signature of electrical engineer of provider

Explanation of column headers:

1. Identity:- Identification mark/number/tag of equipment in single line drawing and layout drawing. Every equipment in single line drawing and layout drawing shall have suitable identification mark/number/tag.
2. Type:- Cable/CB/MCB/MCCB/ELCB/transformer/lightning arrestor/earthing station/ earthing connection/motor/lighting fixture/switch/fuse/switch, socket box etc.
3. Last test date: - latest test date indicated in Form-1A.
4. Next due date of any test:- as worked out by frequency of tests indicated in subsequent columns.
5. Frequency of IR test:- required frequency depending upon type of equipment and location of installation. NA if not required after installation.
6. Frequency of HV test:- required frequency depending upon type of equipment and location of installation. NA if not required after installation.
7. Frequency of earth resistance test:- required frequency depending upon type of equipment and location of installation. NA if not required after installation.
8. Other tests:- name and description of any other essential tests/maintenance activity and required frequency depending upon type of equipment and location of installation. NA if not required after installation.

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26. Indian Standard 13416(Part 5), Recommendations for preventive measures against hazards at workplaces: Part 5 Fire protection, 1994

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LIST OF PARTICIPANTS

EXPERT COMMITTEE FOR REVIEW OF 'GUIDELINES' ON CONTROL OF WORKS

Dates of meeting:	July 9, 2007	July 23, 2007
	September 3, 2007	October 3, 2007
	October 17, 2007	February 22, 2008
	April 4, 2008	April 23, 2008
	May 6, 2008	May 13, 2008
	June 18 & 19, 2008	August 4, 2008
	May 12, 2010	

Members of Sub Committee:

Shri P.B. Kulkarni (Chairman)	:	BARC (Former)
Shri Sushil Kumar	:	DGFASLI
Shri D.K. Jain	:	NPCIL
Shri N. Nagaich	:	NPCIL
Shri P. Lahiri	:	BARC
Shri N. Prasad	:	NPCIL
Shri K. Ramprasad	:	AERB
Shri A.K. Tandle	:	BARC
Shri T.V. Sudhikumaran	:	NPCIL
Shri S.R. Bhave (Member Secretary)	:	AERB

Invitees:

Dr. P.K. Sinha	:	NPCIL (Former)
Shri D. Das	:	AERB

Contributors:

Shri R. Bhattacharya	:	AERB
Shri.S. Sounderarajan	:	BARC
Shri.S.R. Bhave	:	AERB
Shri S. Chockalingam	:	AERB

ADVISORY COMMITTEE ON INDUSTRIAL AND FIRE SAFETY (ACIFS)

Dates of meeting	:	July 6, 2009 August 4, 2009 November 30, 2009 February 22, 2010 March 26, 2010 April 29, 2010 July 30, 2010 September 21, 2010

Member ACIFS:

Shri S.K. Mukherjee (Chairman)	:	HPCL, Mumbai (Former)
Shri R.K. Gupta	:	HPCL, Mumbai
Shri M.P. Mahajan	:	HWB (Former)
Shri H.S. Ahluwalia	:	NFC (Former)
Shri S.K. Ghosh	:	BARC
Shri S.E. Kannan	:	AERB (Former)
Shri N.K. Agarwal	:	NPCIL (Former)
Shri P.K. Ghosh	:	AERB (Former)
Shri R. Bhattacharya	:	AERB
Shri K. Ramprasad (Member-Secretary)	:	AERB

PROVISIONAL LIST OF REGULATORY DOCUMENTS ON INDUSTRIAL AND FIRE SAFETY

Reference No.	Title	Year of Publication
AERB/NF/FPS (Rev. 1)	Fire Protection Systems for Nuclear Facilities	2010
AERB/NRF/SG/ IS-1 (Rev. 1)	Control of Works	2012
AERB/SG/IS-2	Preparation of Safety Report of Industrial Plants other than Nuclear Power Plants in the Department of Atomic Energy	2001
AERB/SG/IS-3	Personal Protective Equipment	004
AERB/SG/IS-4	Guidelines for Pre-employment Medical Examination and fitness for Special Assignment	2005
AERB/SG/EP-3	Preparation of Site Emergency Preparedness Plans for Non-nuclear Installations.	2000
AERB/SG/EP-4	Preparation of Off-site Emergency Preparedness Plans for Non-nuclear Installations.	2000
AERB/SG/D-4	Fire Protection in Pressurised Heavy Water Reactor Based Nuclear Power Plants	1999
AERB/SM/IS-1	Manual on Database Management for Accidents/ Diseases Happening due to Occupation and Implementation of the same in the Department of Atomic Energy	1991

AERB SAFETY GUIDELINES NO. AERB/NRF/SG/IS-1 (Rev. 1)

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Niyamak Bhavan, Anushaktinagar
Mumbai - 400 094
INDIA.

BCS

SPECIFICATION FOR HDPE/SBS WATER PROOFING SYSTEM

1.1 PROTECTIVE COATINGS - ABOVE AND BELOW GROUND

1.1.1 GENERAL

All concrete except the top side of general paving/flooring shall be coated as per the appropriate system described below.

All membranes/coatings shall be applied at not less than seven days and not more than 28 days after curing is completed.

Concrete surfaces shall be dry and free from contamination such as oil, grease, loose particles, surface laitance, form release agents and curing compounds. Concrete surfaces shall be lightly grit blasted or power washed if/as required by the coating MANUFACTURER.

Honey combing, blowholes, hairlines cracks and other surface imperfections shall be filled and repaired prior to any coating application.

Where concrete will be exposed to aggressive chemicals such as acids, brine, hot fumes, etc., special protection systems such as acid resistant brick or epoxy coatings will be specified on the Engineering drawings.

The coating MANUFACTURER shall submit a detailed installation procedure that includes the requirements for surface preparation, priming, application, curing and protection.

The application of all concrete protection system should be executed by the Authorized applicator of manufacturer, who has completed job of said system for minimum area as specified in table-1 during last 5 years. The entire encapsulation system shall be jointly guaranteed by main contractor, applicator and manufacturer of membranes for a period of minimum 10 years.

TABLE: 1

Minimum past work experience required for approved applicator:

Total executable work (combine work of HDPE & SBS membrane) by main contractor in a Tender/ LSTK Package defined by PMC in this job.	Minimum required executed area done by the applicator in previous projects.
<50000 sqm	50% of total executable quantity
>=50000 sqm	25000 sqm

All coatings shall be installed in strict accordance with the MANUFACTURER's instructions. This shall include the MANUFACTURER's recommendations for surface preparation, priming, application, curing and protection.

Representative of the coating MANUFACTURER shall visit the site prior to the commencement of the concrete coating application, for meetings with the Concrete CONTRACTOR and Specialty Applicator and there after regular visit of representative of MANUFACTURER whenever required to ensure that the MANUFACTURER's recommendations and instructions are understood and followed. An ITP shall be established for random inspection by manufacturer representative & complete inspection by applicator & main contractor.

All submissions of membrane and coating shall be accompanied by independent test certification that verifies the properties of the submitted product(s). Testing of membrane shall be done after every **10000 sqm** application of membrane if the membranes are brought from same source else testing of membranes shall be carried out separately for each source if it is brought from different sources.

1.1.2 Below ground protective coating:

All below ground concrete shall be fully encapsulated with one layer of pre-applied fully bonded 1.2 mm (min.) thick HDPE water proofing membrane consisting of HDPE sheet (HDPE should be virgin HDPE & not recycled. Thickness of bare HDPE layer shall not be less than 0.75mm) coated with pre-applied pressure sensitive adhesive layer and a trafficable, non tacky, smooth finish, weather & dirt resistant, non absorbent protective coating covered with a clear release liner at bottom of foundation/raft/pile-cap/tie-beam/plinth beam etc. HDPE membrane shall be placed on the PCC of foundation base/raft/pile cap/plinth beam/tie beam over which concreting shall be done. HDPE membrane shall be projected by 250 mm on all sides of concrete structures from PCC top level. Lap joint between two adjacent HDPE membranes shall be 80 mm minimum.

In addition to above, one layer of minimum 1.5mm thick self-adhesive rubber/bitumen with cross laminated high density polyethylene waterproof membrane (SBS membrane) shall be applied on sides and top of foundation/raft/pile cap/plinth-beam/tie-beam etc. after application of primer on the concrete surface from the junction of HDPE membrane at bottom and upto 250 mm above FGL or upto HPP/FFL level in Unit/Building area. Lapping of minimum 150 mm shall be provided between HDPE & SBS membrane and a single sided HDPE tape shall be provided over the lapping. Mortar fillet of 50 x 50 mm shall be provided at sharp edges of concrete. SBS membrane shall be fixed by aluminum flashing with the concrete structures at FGL/FFL/HPP and filling the top gap with poly-sulphide sealant conforming to IS 12118 as per drawing at termination of membrane.

The membrane shall be capable of resisting tears and punctures from normal construction activities, rebar chairs, concrete spacer blocks, etc. and capable of being exposed to weather and UV light for up to 40 days prior to casting concrete.

The membrane shall have the following minimum properties:

1) Two component Poly-urethane membrane

Property	Standard	Limit
Elongation at break	ASTM D412	>400%
Tensile strength (w/o accelerator)	ASTM D412	>2.5MPa
Adhesion to concrete (concrete surface failure)	ASTM D903 or ASTM D 7234	>2.0 N/mm^2
Hardness (Shore A scale)	ASTM D2240	75
Service Temperature		-30° C to +70° C
Solid content (%)	ASTM C836	>85%

2) SBS membrane

Property	Standard	Limit
Thickness		1.5 mm
Elongation of Film	ASTM D5147 / EN-12311-1/ ASTM D 412	>200%
Puncture resistance	ASTM E154 / EN-12691	> 200 N
Tensile Strength:	ASTM D5147 / ASTM D 882 / ASTM D 412 / EN-12311-1	>4.0 N/ mm^2
Adhesion to primed concrete	ASTM D1000 / ASTM C 794	>1.8 N/mm
Tear resistance : Longitudinal	ASTM D4073 / EN-12310-1	>125 N/mm
Adhesion to self - Lap Adhesion	ASTM D1000	>1.8 N/mm
Moisture Vapor Transmission	ASTM E96 / ASTM D 570 / EN-1931	<0.3g/m2/24hrs
Crack bridging	ASTM C836	>1.5mm
Adhesive Softening point	ASTM D36 or IS :1205/1978	>100°C
Resistance to Hydrostatic head / Hydrostatic water press	DIN 1048 / DIN-16935 / ASTM D 5385	>60 m of water (6 bar)

3) HDPE membrane:

Property	Standard	Limit
Roll size (min)		1.2 m x 20 m
Thickness		1.2 mm
Thickness of Bare HDPE		0.75 mm
Tensile strength, Film	ASTM D 412 Modified	>25 MPa
Elongation	ASTM D 412 Modified	>400 %
Low temp Flexibility	ASTM D1970	unaffected at -23°C
Resistance to Hydrostatic head	ASTM D 5385 Modified	>60 m of water
Peel adhesion to concrete	ASTM D 903 Modified	>880 N/m
Puncture Resistance	ASTM E154 Modified	> 1000 N

(NOTE- Testing Code/Standards shall be ASTM or Equivalent)

The membrane shall extend up to the level of high point of finished grade or paving.

All foundations shall be constructed with membrane system consisting of the following layers (placed in same sequence):

- Vapor barrier, polyethylene of 1000 gauge (0.25mm) thick shall be provided below PCC.
- P.C.C./ lean concrete as per EDB/Drawings.
- 1.2mm thick HDPE membrane with smooth finish shall be provided under foundation/pile-cap/raft etc.
- 1.5mm thick self adhesive SBS Membrane with cross laminated high density polyethylene on the sides of foundation.

All below ground membranes, coatings etc shall be protected from damage due to construction activities, backfilling etc by covering with protection board of 8mm HDPE dimple board having minimum density of 85 kg/m3 & hardness 20 (Shore-A).

Small miscellaneous foundations such as stair/ladder footings, non-equipment footings less than 2m by 1m in plan, and non-hydrocarbon piping service pipe sleepers less than 300mm wide by 500 mm overall depth shall be coated with 500 microns Dry Film Thickness (D.F.T) solvent free coal tar epoxy.

2 coats of coal tar epoxy shall be of High Build solvent free moisture compatible Coal Tar epoxy cured with polyamine hardener @ 250 µ.each
(Two pack polyamine cured epoxy resin blended with coal tar medium, suitable blended)

Total DFT = 2 × 250 = 500 µ

The coating shall have the following minimum properties:

Property	Standard	Limit
Solids Content		100%
Specific Gravity		1.35
Water Absorption	ASTM D570	Nil
Adhesion Strength	ASTM D4541	>1.0 N/mm²
Abrasion resistance	ASTM C944	0.1 g
Linear Shrinkage	ASTM C531	<0.6 mm

The bottom of slabs on grade shall have one layer of 0.25 mm minimum thick polyethylene sheet. Laps shall be a minimum of 300 mm.

The vertical sides of all slabs on grade including process and yard paving shall be coated with four coats of High Build solvent free moisture compatible coal tar epoxy cured with polyamine hardener @ 250 µ DFT each.

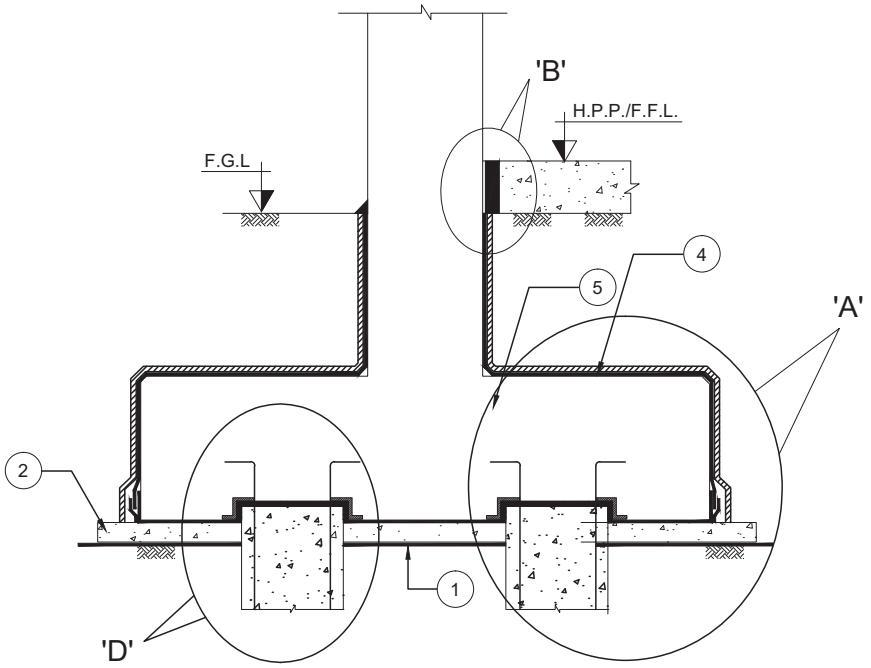
4 coats of High Build Coal Tar epoxy cured with polyamine hardener @ 250 µ.
(Two pack polyamine cured epoxy resin blended with coal tar medium, suitable blended)

Total DFT = 4 × 250 = 1000 µ

Pile head shall be made water proofed by applying 30 mm thick (min) free flow premix type non shrink cementitious grout having 28 days compressive strength not less than 40 N/sqm on top & side of pile head including providing two component polyurethane liquid membrane having consumption of 1.5 kg/sqm (1.5 mm thick) over the cementitious grout as per manufacturer specification.

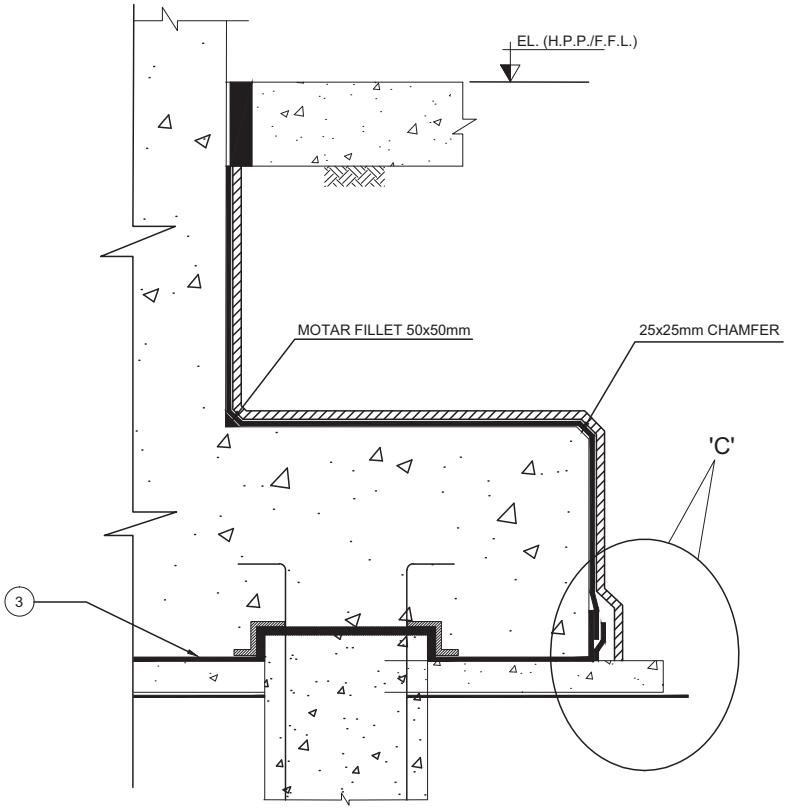
1.1.3 Aboveground protective coatings:

If not otherwise provided with protective coating due to architectural and/ or geo-technical requirements, all concrete elements (where cast in-situ or precast) exposed to atmosphere shall be provided with three coats of cement based waterproof paint as per IS:5410. Prior to application of the paint, the surface shall be prepared to remove all foreign particle, loose materials, extra deposited concrete lumps, etc. using appropriate mechanical/ manual means.

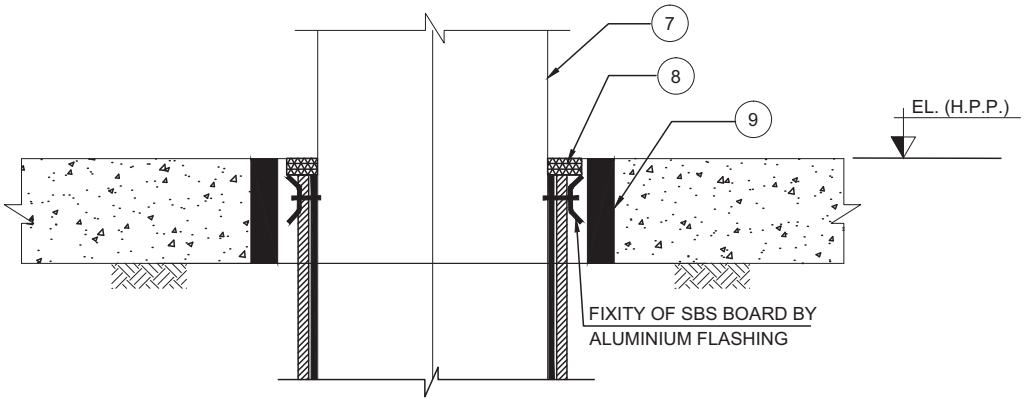


CROSS-SECTION

PROTECTION SYSTEM FOR OPEN/PILE CAP FOUNDATION

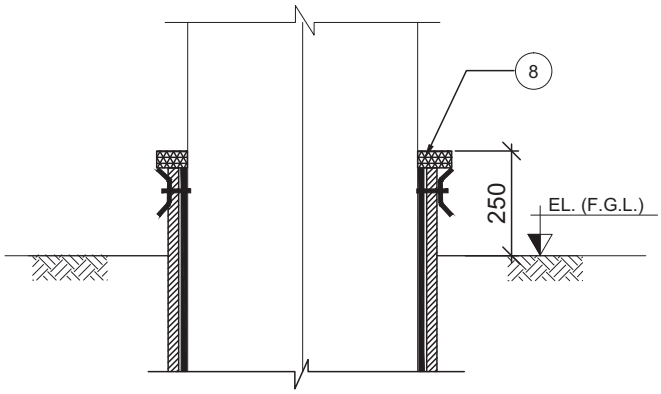


DETAIL -'A'



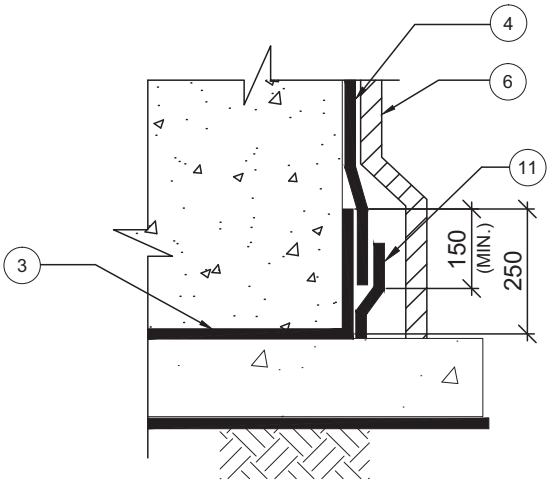
DETAIL -'B'

(TERMINATION DET. OF SBS MEMBRANE IN UNIT AREA)



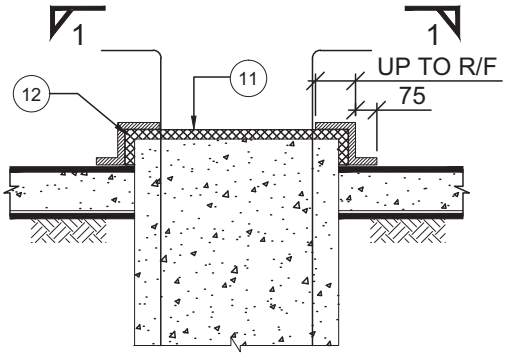
DETAIL -'B'

(TERMINATION DET. OF SBS MEMBRANE IN OFFSITE AREA)

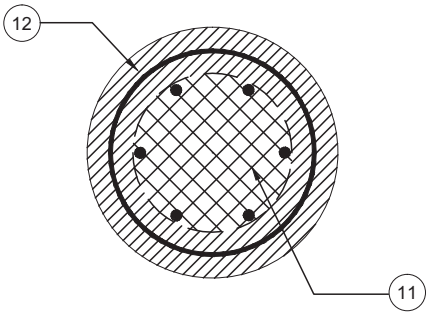


DETAIL -'C'

(SBS & HDPE MEMBRANE OVERLAP AT JOINTS)



DETAIL -'D'



VIEW 1-1

NOTES :–

1. VAPOUR BARRIER , POLYETHYLENE OF 0.25mm THICK.
2. P.C.C. / BLINDING CONCRETE.
3. 1.2mm THICK HDPE MEMBRANE ON BOTTOM OF FOUNDATION / PILECAP.
4. 1.5mm THICK SBS MEMBRANE.
5. CONCRETE FOUNDATION.
6. MEMBRANE PROTECTION BOARD BY 8mm HDPE DIMPLE BOARD.
7. ABOVE GROUND 3 COAT OF CEMENT BASED WATERPROOF PAINT AS PER IS:5410 (U.N.O).
8. POLYSULPHIDE SEALANT.
9. BITUMEN IMPREGNATED FIBRE BOARD.
10. SINGLE SIDE HDPE TAPE.
11. CEMENTITIOUS GROUT- 30mm THICK (MIN.).
12. LIQUID MEMBRANE (CONSUMPTION OF 1.5 kg/sqm).

VOLUME: II B

SECTION - D

SUB-SECTION – D1

EARTHWORK IN EXCAVATION AND BACKFILLING

SPECIFICATION NO. PE-TS-999-600-C001

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
1.00.0	SCOPE	3
2.00.00	GENERAL	3
3.00.00	EXECUTION	6
4.00.00	TESTING AND ACCEPTANCE CRITERIA	19
5.00.00	RATES AND MEASUREMENTS	19
6.00.00	INFORMATION TO BE SUBMITTED BY THE BIDDER	20

STANDARD TECHNICAL SPECIFICATION FOR EARTHWORK IN EXCAVATION AND BACKFILLING

1.0.0 SCOPE

This specification covers earth work excavation in all types of soil, soft rock and hard rock including setting out, clearing and grubbing, shoring, dewatering, back filling around foundations/pipelines to grade, watering, compaction of fills, testing, approaches, disposal of surplus earth, protective fencing, lighting etc relevant to the structures and locations covered under this contract.

2.0.0 GENERAL

2.1.0 Work to be provided for by the Contractor

The work to be provided for by the contractor unless specified otherwise shall include but not be limited to the following.

a) Supplying and providing all labour, supervision services, earth moving machineries, surveying instruments including facilities as required under statutory labour regulations, materials, scaffolds, equipment, tools and plants, transportation, etc. required for the work.

b) Preparation and submission of working drawings showing the approaches, slopes, berms, shoring, sumps for dewatering including drainage, space for temporary stacking of soils, disposal area, fencing etc and all other details as may be required by the engineer.

c) To carry tests and submit to the Engineer, test results of fill materials and degree of soil compaction of fill whenever required by the Engineer to assess the quality of fill.

d) Design, construction and maintenance of Magazine of proper capacity for storage of explosives for blasting work and removal of the same after completion of the work etc. including procurement of necessary licenses from proper authorities.

2.2.0 Work to be provided by others

No work under this specification will be provided by any agency other than the contractor unless specifically mentioned elsewhere in the contract.

2.3.0 Codes and Standards

All works shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes unless specified otherwise.

IS-1200	Method of measurement of building and civil engineering works, Part-I: Earthwork
IS-2720	Method of test for soils (Relevant parts)
IS-3764	Excavation work - Code of safety
IS-4081	Safety code for blasting and related drilling operations
IS-4701	Indian Standard Code of Practice for earthwork on Canals
IS:6922	Criteria for safety and design of structures subject to underground blasts
IS: 3764	Excavation work – code of safety

In case of conflict between this specification and those (IS Codes) referred to herein, the former shall prevail. In case any particular aspect of work is not covered specifically by this specification/IS Codes, any other standard practice as may be specified by the engineer shall be followed.

2.4.0 Conformity with Designs

The contractor shall carry out the work as per the approved drawings, specification and as directed by the engineer.

2.5.0 Materials

2.5.1 General

All materials required for the work shall be of the best commercial variety and approved by the engineer.

2.5.2 Material for Excavation

For the purpose of identifying the various strata encountered during the course of excavation, refer clause no. 3.4.0 for the classification of earth strata.

2.5.3 Material for Filling

Material to be used for back filling shall be free from vegetations, roots, salts, rubbish, lumps, organic matter and any other harmful chemicals etc and shall be got approved by the engineer. Normally excavated earth shall be used for back filling. In case such earth contains deleterious salts, the same shall not be used. All clods of earth shall be broken or removed. Where the excavated material is mostly rock and if filling with the same is permitted by the engineer in writing, then the filling with rock shall be done in the following

manner. The boulders shall be broken into pieces not exceeding 150mm size in any direction and mixed with fine materials consisting of decomposed rock, moorum or any approved earth to fill the voids as for as possible and the mixture shall then be used for filling.

In case the earth required for backfilling is over and above the earth available from the compulsory excavations within the project area, then borrow areas for obtaining suitable fill material shall be arranged by the contractor himself from outside the plant boundary limits and all expenses including royalties, taxes, duties etc shall be borne by him. The selected earth from the borrow areas shall be got approved by the engineer. The borrowed material shall be free from roots, vegetations, decayed organic matter, harmful salts and chemicals, free from lumps and clods etc. The contractor shall obtain and submit necessary clearances/permissions from the concerned authorities for the borrow areas/materials acquired to the engineer.

If specified, the back filling shall be done with clean well graded sand from approved quarries free from harmful and deleterious materials.

2.6.0 Quality Control

All works shall confirm to the lines, levels, grades, cross sections and dimensions shown on the approved drawings and/or as directed by the engineer. The contractor shall establish and maintain quality control for the various aspects of the work, method of construction, materials and equipments used etc. The quality control operation shall include but not be limited to the following.

Sl. No.	Activity	Check
1	Lines, levels & grades	a) By periodic surveys b) By establishing markers, boards etc
2	Back filling	(a) On quality of fill material (b) On moisture content of back fill (c) On degree of compaction achieved

2.7.0 Information regarding site conditions

Surface and Sub-surface data regarding the nature of soil, rock, sub-soil water etc. shown on drawing or otherwise furnished to the Contractor shall be taken as a guidance only and variation therefrom shall not affect the terms of the contract. The Contractor must satisfy himself regarding the character and volume of all work under this contract and expected surface, sub-surface and / or sub-soil water to be encountered. He must also satisfy himself about the general conditions of site and ascertain the existing and future construction

likely to come up during the execution of the contract so that he may evolve a realistic programme of execution.

3.0.0 EXECUTION

The contractor shall prepare and submit the detailed drawings/schemes for excavation and back filling works as proposed to be executed by him showing the dimensions as per the construction drawings and specification adding his proposal of slopes, shoring, approaches, dewatering, drainage, berms etc. for the approval of engineer.

3.1.0 Setting out

On receiving the approval from the engineer with modifications and corrections if any, the contractor shall set out the work from the control points furnished by the engineer and fix permanent points and markers for ease of periodic checking as the work proceeds. These permanent points and markers shall be fixed at the interval as prescribed by the engineer and shall be got checked and certified by the engineer after whom the contractor shall proceed with the work. It should be noted that this checking by the engineer prior to the start of the work will in no way relieve the contractor of his responsibility of carrying out the work to true lines, levels and grades as per the drawings and specification. If any errors are noticed in the contractor's work at any stage, the same shall be rectified by the contractor at his own risk and cost.

3.2.0 Initial Levels

Initial levels of the ground either in a definite grid pattern or as directed by the Engineer will be taken by the Contractor jointly with the Engineer over the original ground prior to starting actual excavation work and after setting out. These initial levels will be used for preparing cross-sections for volume measurement or for cross-checking the depths obtained from tape measurements. All records of levels, measurements etc. and also any drawing, cross-section etc. made therefrom, shall be jointly signed by the authorised representative of the contractor and the Engineer before the commencement of work and they shall form the basis of all payments in future.

3.3.0 Clearing and Grubbing

The area to be excavated shall be cleared out of fences, trees, logs, stumps, bushes, vegetation, rubbish, slush etc. Trees upto 300mm girth shall be uprooted. Trees above 300mm girth to be cut shall be approved by the engineer and marked. Cutting of trees shall include removing roots as well. After the tree is cut and roots taken out, the pot holes formed shall be filled with good earth in 250mm layers and compacted unless directed otherwise by the engineer. The trees shall be cut in to suitable pieces as instructed by the

engineer. Before earthwork is started, all the spoils, unserviceable materials and rubbish shall be burnt or removed and disposed to the approved disposal area(s) as specified by the engineer. Useful materials, saleable timber, fire woods etc shall be the property of the owner and shall be stacked properly at the worksite in a manner as directed by the engineer.

3.4.0 Classification

All earthwork shall be classified under the following categories:

No distinction will be made whether the material is dry or wet.

a) **Ordinary Soil**

This shall comprise vegetable or organic soil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose moorum, a mixture of these and similar material which yields to the ordinary application of pick and shovel, rake or other ordinary digging implement. Removal of gravel or any other nodular material having diameter in any one direction not exceeding 75 mm occurring in such strata shall be deemed to be covered under this category.

b) **Hard Soil**

This shall include :
i) stiff heavy clay, hard shale, or compact moorum requiring grafting tool or pick or both and shovel, closely applied ;
ii) gravel and cobble stone having maximum diameter in any one direction between 75 and 300 mm ;
iii) soling of roads, paths, etc., and hard core ;
iv) macadam surfaces such as water bound, and bitumen/tar bound;
v) lime concrete, stone masonry in lime mortar and brick work in lime/cement mortar, below ground level ;
vi) soft conglomerate, where the stones may be detached from the matrix with picks ; and
vii) generally any material which requires the close application of picks, or scarifiers to loosen and not affording resistance to digging greater than the hardest of any soil mentioned in (i) and (vi) above.

c) **Soft and Decomposed Rock**

This shall include :
i) limestone, sandstone, laterite, hard conglomerate or other soft or disintegrated rock which may be quarried or split with crowbars ;
ii) unreinforced cement concrete which may be broken up with crowbars or picks and stone masonry in cement mortar below ground level ;
iii) boulders which do not require blasting having maximum diameter in any direction of more than 300 mm, found lying loose on the surface or embedded

in river bed, soil, talus, slope wash and terrace material of dissimilar origin ; and
iv) any rock which in dry state may be hard, requiring blasting, but which when wet becomes soft and manageable by means other than blasting.

d) **Hard Rock (requiring blasting)**

This shall include :
i) any rock or cement concrete for the excavation of which the use of mechanical plant or blasting is required ;
ii) reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level; and
iii) boulders requiring blasting.

e) Hard Rock (blasting prohibited)

Hard rock requiring blasting as described under (d) but where blasting is prohibited for any reason and excavation has to be carried out by chiselling, wedging or any other agreed method.

In case of any dispute regarding classification, the decision of the Engineer shall be final.

3.5.0 Excavation for Foundations and Trenches

3.5.1 General

All excavation shall be done to the minimum dimensions as required for the safety and working facility. In each individual case, the contractor shall obtain prior approval of the engineer for the method he proposes to adopt for the excavation including dimensions, side slopes, shoring, dewatering, drainage and disposal etc. This approval however shall not in any way make the engineer responsible for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. All excavation in open cuts shall be made true to the line, slopes and grades as shown on the drawings and/or as directed by the engineer. No material shall project within the dimension of minimum excavation lines marked. Boulders (if any) projecting out of the excavated surfaces shall be removed if they are likely to be a hindrance to the work/workers in the opinion of the engineer.

Method of excavation shall in every case be subject to the approval of the engineer. The contractor shall ensure the stability and safety of the excavation, adjacent structures, services and works etc including the safety of the workmen. If any slip occurs, the contractor shall remove all the slipped materials from the excavated pit without any extra cost to the engineer/owner. All loose boulders and semi detached rocks which are not inside but so close to the area to be excavated and may liable to fall or otherwise endanger the

workmen, equipment of the work etc during excavation in the opinion of the engineer shall be stripped off and removed away from the area of excavation. The method to be used for removal shall be such that it should not shatter or render unstable or unsafe the portion which was originally sound and safe. In case any material not required to be removed initially but later to become loose or unstable in the opinion of the engineer shall also be promptly and satisfactorily removed.

The rough excavation may be carried out upto a maximum depth of 150 mm above the final level. The balance shall be excavated with special care. If directed by the engineer, soft and undesirable spots shall be removed even below the final level. The extra excavation shall be filled up as instructed by the engineer. If the excavation (in all types of soil and rock) is done to a depth greater than that shown on the drawing or as directed by the engineer, the excess depth up to the required level shall be filled with cement concrete not leaner than 1:4:8 or richer as directed by the engineer at the own risk and cost of the contractor. In case where excavation in soil, soft rock (including weathered rock) and hard rock are involved, the excavation in each stratum shall be carried out separately with the approved methodology and as per the instructions of the engineer.

All excavated materials such as rock, boulders, bricks, dismantled concrete blocks etc shall be the property of the owner and shall be stacked separately as directed by the engineer. All gold, silver, oil, minerals, archeological and other findings of importance, trees cut or other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or upon the site shall be the property of the owner and the contractor shall duly preserve the same to the satisfaction of the engineer/owner. The contractor shall deliver the same to such person or persons as may be authorized or appointed from time to time by the owner to receive the same.

Prior to starting the excavation, the ground level at the location shall be checked jointly with the engineer.

3.5.2 Excavation in All Type of Soil and in Soft Rock

The excavation in all type of soil, soft rock including decomposed rock etc shall be carried out as per the approved proposal and as directed by the engineer. The work shall be carried out in a workmanlike manner without endangering the safety of nearby structures/services or works and without causing hindrance to any other activities in the area. Foundation pits shall not be excavated to the full depth unless construction is imminent. The last 150mm depth shall be excavated once concreting work is imminent. At the discretion of the engineer, the full depth may be excavated and the bed be covered with lean concrete as specified after watering and compacting the bed. As the excavation reaches the required dimensions, lines, levels and grades

etc, the work shall be got checked and approved by the engineer. In cases where deterioration of the ground, upheaval, slips etc are expected, the engineer may order to suspend the work at any stage and instruct the contractor to carry out the protection works before the excavation will be restarted.

3.5.3 Excavation in Hard Rock

Hard rocks shall normally be excavated by means of blasting. In case where blasting is prohibited for any reasons, the excavation shall be carried out by chiselling or any other approved method as directed by the engineer. Personnel deployed for rock excavation shall be protected from all hazards such as loose rock/boulder rolling down and from general slips of excavated surfaces. Where the excavated surface is not stable against sliding, necessary supports such as props, bracings or bulkheads shall be provided and maintained during the period of construction. Where the danger of falling loose rock/boulder from the excavated surfaces deeper than 2m exist, steel mesh anchored to the lower edge of the excavation and extending over and above the rock face adequate to retain the dislodged material shall be provided and maintained.

3.5.4 Blasting

Storage, handing and use of explosives shall be governed by the current explosive rules/regulations laid down by the Central and the State Governments. The contractor shall ensure that these rules/regulations are strictly adhere to. The following instructions are also to be strictly followed and the instructions wherever found in variance with the above said rules/regulations, the former (instructions) shall be superseded with the later (above said rules/regulations).

No child under the age of 16 and no person who is in a state of intoxication shall be allowed to enter the premises where explosives are stored nor they shall be allowed to handle the explosives. The contractor shall obtain licence from the District Authorities for undertaking the blasting work as well as for obtaining and storing the explosives as per Explosives Rules, 1940 corrected upto date. The contractor shall purchase the explosives, fuses, detonators etc only from a licensed dealer and shall be responsible for the safe custody and proper accounting of the explosive materials. The engineer or his authorized representative shall have the access to check the contractor's store of explosives and his accounts at any time. It is the full responsibility of the contractor to transport the explosives as and when required for the work in a safe manner to the work spot.

Further, the engineer may issue modifications, alterations and new instructions to the contractor from time to time. The contractor shall comply with the same without these being made a cause for any extra claim.

3.5.4.1 Materials

All materials such as explosives, detonators, fuses, tamping materials etc proposed to be used in the blasting operation shall have the prior approval of the engineer. Only explosives of approved make and strength are to be used. The fuses known as instantaneous fuse must not be used. The issue of fuse with only one protective coat is prohibited. The fuse shall be sufficiently water resistant as to be unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and shall be not less than 4 seconds per inch of length with 10% tolerance on either side. Before use, the fuse shall be inspected. Moist, damaged or broken ones shall be discarded. When the fuses are in stock for long, the rate of burning of fuses shall be tested before use. The detonators shall be capable of giving an effective blasting of the explosives. Moist and damaged detonators shall be discarded.

3.5.4.2 Storage of Explosives

The current Explosive Rules shall govern the storage of explosives. Explosives shall be stored in a clean, dry and well ventilated magazine to be specially built for the purpose. Under no circumstances should a magazine be erected within 400m of the actual work site or any source of fire. The space surrounding the magazine shall be fenced and the ground inside shall be kept clear and free from trees, bushes etc. The admission to this fenced space shall be through a single gate only and no person shall be allowed without the permission of the officer-in-charge. The clear space between the fence and the magazine shall not be less than 90m. The magazine shall be well drained. Two lightning conductors, one at each end shall be provided to the magazine. The lightning conductors shall be tested once in every year.

Explosives, fuses and detonators shall each be separately stored. Cases of explosives must be kept clear of the walls and floors for free circulation of air on all sides. Special care shall be taken to keep the floor free from any grains of explosives. Cases containing explosives shall not be opened inside the magazine and the explosives in open cases shall not be received into a magazine. Explosives which appear to be in a damaged or dangerous condition are not to be kept in any magazine but must be removed without delay to a safe distance and be destroyed.

Artificial light, matches, inflammable materials, oily cotton, rag waste and articles liable to spontaneous ignition shall not be allowed inside the magazine. Illumination shall be obtained from an electric storage battery lantern. No smoking shall be allowed within 100m distance from any magazine.

Magazine shoes without nails shall be used while entering the magazine. The persons entering the magazine must put on the magazine shoes which shall be

provided at the magazine for this purpose and should be careful

* not to put their feet on the clean floor unless the magazine shoes on.

* not to touch the magazine shoes on ground outside the clean floor.

* not to allow any dirt or grit to fall on the clean floor.

Persons with bare feet shall dip their feet in water before entering the magazine and then step directly from the tub to the clean floor. No person having article of steel or iron with/on him shall be allowed to enter the magazine. Workmen shall be examined before entering the magazine to check none of the prohibited articles are with them. A brush broom shall be kept in the lobby of the magazine for cleaning the magazine. Cleaning shall be done immediately after each occasion whenever the magazine is opened for receipt, delivery or inspection of the explosives.

The mallets, levers, wedges etc for opening the barrels or cases shall be of wood. The cases of explosives are to be carried by hand and shall not be rolled or dragged inside the magazine. Explosives which have been issued and returned to the magazine are to be issued first; otherwise those which have been stored long in the store are to be issued first. Neither the magazine shall be opened nor any person shall be allowed in the vicinity of the magazine during any dust storm or thunderstorm. All magazines shall be officially inspected at definite intervals and a record of such inspections shall be kept.

3.5.4.3 Carriage of Explosives

Detonators and explosives shall be transported separately to the blast site. Explosives shall be kept dry and away from direct rays of the sun, artificial lights, steam pipes or heated metal and other sources of heat. Before explosives are removed, each case or package shall be carefully examined to ascertain that it is properly closed and shows no sign of leakage.

No person except the driver shall be allowed to travel on the vehicle conveying explosives. No explosive shall be transported in a carriage or vessel unless all iron or steel therein the carriage or vessel which are likely to contact the package containing explosives are effectually covered with lead, leather, wood, cloth or any other suitable material. No light shall be carried on the vehicle carrying explosives and no operation connected with the loading, unloading and handling of explosives shall be conducted after sunset.

3.5.4.4 Use of Explosives

The contractor shall appoint an agent who shall personally superintend the firing and all operations connected therewith. The contractor shall satisfy himself that the person so appointed is fully acquainted with his

responsibilities.

Holes for charging the explosives shall be drilled with pneumatic drills and the drilling pattern shall be so planned that the rock pieces after blasting will be suitable for handling. The hole diameter shall be of such a size that the cartridges can easily pass down through them and any undue force is not required during charging. Charging operation shall be carried out by or under the personal supervision of the shot firer. Wrappings shall never be removed from the explosive cartridges. Only one cartridge at a time shall be inserted in a hole and wooden rods shall only be used for loading and stemming the shot holes. Only such quantities of explosives as are required for a particular work shall be brought to the work site. Should any surplus remain when all the holes have been charged shall be carefully removed to a point at least 300m away from the firing point.

The authorized shot firer himself shall make all the connections. The shot firing cable shall not be dragged along the ground to avoid any damage to the insulation. The shot firing cable shall be tested each time for its continuity and possible short circuiting. The shot firer shall always carry the exploder handle with him until he is ready to fire shots. The number of shots fired at a time shall not exceed the permissible limits. Before any blasting is carried out it shall be ensured that all workmen, vehicles and equipment on the site are cleared from an area of minimum 300m radius from the firing point or as required by the statutory regulations at least 10 minutes before the time of firing by sounding a warning siren and the area shall be encircled by red flags.

The explosives shall be fired by means of an electric detonator placed inside the cartridge. For simultaneous firing of a number of charges, the electric detonators shall be connected with the exploder through the shot firing cable in a simple series circuit. Due precautions shall be taken to keep the firing circuit insulated from the ground, bare wires, rails, pipes or any other path of stray current etc and keep the lead wires short circuited until it is ready to fire. Any kink in the detonator leading wire shall be avoided. For simultaneous firing of a large number of shot holes, use of cordtex may be done. An electric detonator attached to its side with adhesive tape shall initiate cordtex connecting wire or string. Blasting shall only be carried out at certain specified times to be agreed jointly by the contractor and the engineer.

At least five minutes after the blast has been fired in case of electric firing or as stipulated in the regulations, the authorized shot firer shall return to the blast area and inspect carefully the work and satisfy himself that all the charged holes have exploded. Cases of misfired unexploded charges shall be exploded by drilling a parallel fresh hole at a distance of not less than 600mm from the misfired hole and by exploding a new charge. The authorized shot firer shall be present during the removal of debris as it may contain unexploded explosives near the misfired hole. The workmen shall not return to the site of firing until at least half an hour after firing.

Where blasting is to be carried out in proximity of other structures, controlled blasting by drilling shallow shot holes and proper muffling arrangements with steel plates loaded with sand bags etc shall be used on top of the blast holes to prevent the rock fragments from causing any damage to the adjacent structures and other properties. Adequate safety precautions as per building byelaws, safety codes, statutory regulations etc shall be taken during blasting operations.

3.5.4.5 Restrictions in Blasting

a) Blasting which may disturb or endanger the stability, safety or quality of the adjacent structures/foundations shall not be permitted.
b) Blasting within 200m of a permanent structure or construction work in progress shall not be permitted.
c) Progressive blasting shall be limited to two third of the total remaining depth of excavation.
d) No large scale blasting operations will be resorted to when the excavation reaches the last one metre and only small charge preferably black powder may be allowed so as not to shatter the parent rock.
e) The last blast shall not be more than 0.50 m in depth.
f) In rocky formations, at locations where specifically indicated or ordered in writing by the engineer, the use of explosives shall be discontinued and excavation shall be completed by chiselling or any other suitable method as approved by the engineer.

3.5.5 Disposal

The excavated spoils shall be disposed of in any (or all) of the following manner as directed by the engineer.

a) By using it straightway for backfilling.

b) By stacking it temporarily to use for backfilling at a later date during execution of the contract.

c) i) By either spreading
or
ii) By spreading and compacting at designated disposal areas.

a) By selecting the useful material and stacking it neatly in designated areas as indicated by the engineer for use in backfilling by some other agency.

3.5.6 Disposal of Surplus Materials

All surplus material from excavation shall be removed and disposed of from the excavation site to the designated disposal area indicated by the engineer.

All good and sound rocks obtained from excavations and all assorted materials of dismantled structures are the property of the owner and if the contractor wants to use it, he shall have to obtain it from the engineer at a mutually agreed rate. All sound rocks and other assorted materials like excavated bricks etc shall be stacked separately.

3.5.7 Protection

The contractor shall notify the engineer as soon as the excavation is expected to be completed within a day so that he shall inspect it at the earliest. Immediately after approval of the engineer, the excavation must be covered up in a shortest possible time. But in no case the excavation shall be covered up or worked on before approval by the engineer. Excavated material shall be placed 1.5m or half the depth (of excavation) whichever is more from the edge of the excavation or further away if directed by the engineer. Excavation shall not be carried out below the foundation level of the structure close by until the required precautions are taken. Adequate fencing is to be made enclosing the excavation. The contractor shall protect all the underground services exposed during excavation. All existing surface drains in the work area shall be suitably diverted by the contractor before taking up excavation to maintain the working area neat and clean.

3.5.8 Dealing with Surface Water

All working areas shall be kept free of surface water as far as reasonably praticable. Works in the vicinity of cut areas shall be controlled to prevent the ingress of surface water.

No works shall commence until surface water streams have been properly intercepted , redirected or otherwise dealt with.

Where works are undertaken in the monsoon period, the Contractor may need to construct temporary drainage systems to drain surface water from working areas.

3.5.9 Dewatering

All excavation shall be kept free of water and slush. Grading in the vicinity shall be controlled to prevent the surface water running into the excavations. The contractor shall remove any water inclusive of rain water and subsoil water etc accumulated in the excavation by pumping or other means as approved by the engineer and keep the excavations dewatered and/or lower the subsoil water level to 300mm below the founding level until the construction of foundation and backfilling are completed in all respects.

Sumps made for dewatering must be kept clear of the foundations. The engineer’s prior approval on the method of pumping to be adopted shall be

taken; but in any case, the pumping arrangement shall be such that there shall be no movement or blowing in of subsoil due to the differential head of water during pumping.

3.5.10 Timber Shoring

Close or open type timber shoring as approved by the engineer depending on the nature of sub-soil, depth of pit or trench and the type of timbering shall be adopted. Timbers made out of approved quality shall only be used. It shall be the responsibility of the contractor to take all necessary steps to prevent the sides of trenches and pits from collapsing.

3.5.10.1 Close Timbering

Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called "polling boards". These shall be of 250mm wide(min.) and 40mm thick(min.) sections as directed by the engineer. The boards shall generally be placed vertically in pairs, one on each side of the cut and shall be kept apart (maximum spacing is limited to 1.20m) by horizontal walers of strong wood cross strutted with wooden struts or as directed by the engineer. The length of wooden struts shall depend on the width of the trench or pit.

In case where the soil is very soft and loose, the boards shall be placed horizontally against the sides of excavation and supported by vertical walers which shall be strutted to similar timber pieces on the opposite face of the trench or pit. The lowest board supporting the sides shall be taken into the ground. No portion of the vertical side of the trench or pit shall remain exposed to avoid any slipping out of earth.

The withdrawal of the timber shall be done very carefully to prevent the collapse of the pit or trench. It shall be started from one end and proceeded systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried.

3.5.10.2 Open Timbering

In case of open timbering, vertical board of 250mm wide(min.) and 40mm thick(min.) shall be spaced sufficiently apart to leave unsupported strips of maximum 500mm average width. The detailed arrangement, size of timber and the spacing etc shall be subjected to the approval of the engineer. In all other respects, the specification for close timbering shall apply to open timbering as well.

3.6.0 Treatment of Slips

The contractor shall take all precautions to avoid high surcharges and provide proper surface drainage to prevent flow of water over the sides of the excavations. These precautions along with proper slopes, berms, shoring and control of ground water should cause no slips to occur. If however slips still occur, the same shall be removed by the contractor with his own risk and cost.

3.7.0 Backfilling

3.7.1 General

The material to be used for backfilling shall be approved by the engineer which shall be obtained directly from the excavation, from the nearby areas where excavation work by the same agency is in progress, from the temporary stacks of excavated spoils or from the borrow pits as directed by the engineer. The material shall be free from lumps and clods, roots and vegetations, harmful salts and chemicals, organic materials etc.

In locations where sand filling is required, the sand used should be clean, well graded and be of the quality normally acceptable for use in concrete.

3.7.2 Filling and Compaction in Pits and Trenches all Around the Structures

As soon as the work in foundation has been accepted, the spaces around the foundation in pits and trenches shall be cleared of all debris, brick bats, mortar droppings etc and filled with approved earth in layers not exceeding 250mm (in loose thickness). Each layer(loose) shall be watered, rammed and properly compacted to the required degree to the satisfaction of the engineer. Earth shall be compacted with approved mechanized compaction machine. Usually, no manual compaction shall be allowed unless specifically permitted by the engineer. The moisture content of the fill material during compaction shall be controlled near to its optimum moisture content so as to obtain the required degree of compaction. The final surface shall be trimmed and levelled to proper profile as desired by the engineer.

3.7.3 Plinth Filling

The plinth shall be filled with earth in layers not exceeding 250mm (in loose thickness) and each layer shall be watered and compacted to the required degree with approved compaction machine or manually if specifically permitted by the engineer. When the filling reaches the finished level, the surface shall be flooded with water for at least 24 hours, allowed to dry and then rammed and compacted in order to avoid any settlement at a later stage. The finished surface of fill shall be trimmed to the slope intended to be provided for the floor.

3.7.4 Filling in Trenches for Water Pipes and Drains

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed. Where the trenches are excavated in soil, the filling shall be done with earth on the sides and top of pipes in layers not exceeding 150mm, watered, rammed and compacted taking care that no damage is caused to the pipe below.

In case of trenches excavated in rock, the filling upto a height of 300mm or the diameter of the pipe whichever is more above the crown of the pipe or barrel shall be done with fine material such as earth, moorum, disintegrated rock or ash as per the availability at site and shall be filled in compacted layers not exceeding 150mm. The remaining filling shall be done in layers with the mixture of boulders (of size not exceeding 150mm) and fine material as specified elsewhere in the specification. Each layer shall be watered, rammed and compacted to the required degree and to the satisfaction of the engineer.

3.7.5 Filling in Disposal Area

Surplus materials from excavation which are not required for backfilling shall be disposed of in the designated disposal areas. The spoils shall not be dumped haphazardly but should be spread in layers approximately 250mm thick when loose, watered and compacted with the help of a compacting equipment as per the directions of the engineer. In wide areas, rollers shall be employed and compaction shall be done to the satisfaction of the engineer at the optimum moisture content which shall be checked and controlled by the contractor. In certain cases the engineer may direct the contractor to dispose the surplus materials without compaction which can be done by tipping the spoils from a high bench neatly maintaining a proper level and grade of the bench.

3.8.0 Approaches and Fencing

The contractor should provide and maintain proper approaches for the workmen and inspection. The roads and approaches around the excavation should be kept clear at all times so that there is no hindrance to the movement of men, material and equipment of various agencies connected with the project. Sturdy and elegant fencing is to be provided around the top edge of the excavation as well as around the bottom of the fill at the surplus disposal area where dumping from a high bench is in progress.

3.9.0 Lighting

Full scale area lighting is to be provided if night work is permitted or directed by the engineer. If no night work is in progress, red warning lights should be provided at the corners of the excavated pit and the edges of the fill.

4.0.0 TESTING AND ACCEPTANCE CRITERIA

4.1.0 Excavation

On completion of excavation, the dimension of the pits will be checked as per the drawings after the pits are completely dewatered. The work will be accepted after all undercuts have been set right and all over excavations are filled back to the required lines, levels and grades by placing ordinary cement concrete of 1:4:8 proportion and/or richer and/or by compacted earth as directed by the engineer. The choice of the grade of concrete will be a matter of unfettered discretion of the engineer. Over excavation of the sides shall be made good by the contractor while carrying out the backfilling. The excavation work will be accepted after the above requirements are fulfilled and all the temporary approaches encroaching inside the excavation have been removed.

4.2.0 Backfilling

The degree of compaction required will be as per the stipulation laid down in IS:4701 and the actual method of measuring the degree of compaction will be as decided by the engineer. The work of back filling will be accepted after the engineer is satisfied with the degree of compaction achieved.

5.0.0 RATES AND MEASUREMENTS

5.1.0 Rates

a) The item of work in the schedule of quantities describe the work very briefly. The various items of the schedule of quantities shall be read in conjunction with the corresponding section in the technical specification including amendments and additions if any. For each item in the schedule of quantities, the bidder's rate shall include all the activities covered in the description of the items as well as for all necessary operations in detail as described in the technical specification.

b) No claims shall be entertained if the details shown on the released for construction drawings differ in any way from those shown on the tender drawings.

c) The unit rate quoted shall include minor details which are obviously and fairly intended and which may not have been included in these documents but are essential for the satisfactory completion of the work.

d) The bidder's quoted rate shall be inclusive of supplying and providing all labour, men, materials, equipments, tools and plants, supervision, services, approaches, schemes etc.

f) In case blasting in hard rock is envisaged, the unit rate quoted for earth work shall include the cost of storage and safety arrangements for the materials required for blasting. No separate payment will be made on this account.

5.2.0 Measurements

Method of measurements are specified as below:

a) The length, breadth and depth shall be measured correct to the nearest centimeter if measurements are taken by tape. Rounding of numerical shall be as per relevant IS Codes. If the measurements are taken with staff and level, the levels shall be recorded correct to 5mm. The area and volume shall be worked out in square meter and cubic meter respectively correct to the nearest of two decimal places.

b) For earth work in excavation, the ground levels shall be taken before and after completion of the work in the actually excavated area. The quantity of earth work in excavation shall be computed from these levels in cubic meter.

c) In case of open footings (rafts/ pilecaps/ drains/ cable trench/ pipe trench/ sub soil beams etc.) up to the depth of 2.0 metres, alround excavation of 30 cm beyond the outer dimension of footing (not the PCC dimension below footing) shall be measured for payment to make allowances for centering and shuttering. Any additional excavation beyond this limit shall be at the risk and cost of the contractor and shall not be measured for payment for excavation, backfilling, carriage, dewatering etc. item of work in the schedule of quantities. (Required shoring & strutting, side slopes, benching, dewatering sump pits, approaches to the excavated pit etc. are deemed to be included in item of work in the schedule of quantities).

d) In case of open footings (Rafts/ pilecaps / drains/ cable trench/ pipe trench/ sub soil beams etc.) at a depth of more than 2.0 metre, alround excavation of 75 cm beyond the outer dimension of footing (not the PCC dimension below footing) shall be measured for payment to make allowances for centering and shuttering. Any additional excavation beyond this limit shall be at the risk and cost of the contractor and shall not be measured for payment for excavation, backfilling, carriage, dewatering etc. item of work in the schedule of quantities. (Required shoring & strutting, side slopes, benching, dewatering sump pits, approaches to the excavated pit etc. are deemed to be included in item of work in the schedule of quantities).

e) IN TRENCHES FOR BURIED PIPES & CABLES

Width of Trench

i) Upto one metre depth the authorized width of trench for excavation

shall be arrived at by adding 25 cm to the external diameter of pipe (not socket/ collar) cable, conduit etc. Where a pipe is laid on concrete bed/ cushioning layer, the authorized width shall be the external diameter of pipe (not socket/ collar) plus 25 cm or the width of concrete bed/ cushioning layer whichever is more.

ii) For depths exceeding one metre, an allowance of 5 cm per metre of depth for each side of the trench shall be added to the authorized width (that is external diameter of pipe plus 25 cm) for excavation. This allowance shall apply to the entire depth of the trench. In firm soils the sides of the trenches shall be kept vertical upto depth of 2 metres from the bottom. For depths greater than 2 metres, the excavation profiles shall be widened by allowing steps of 50 cm on either side after every two metres from bottom. Where the soil is soft, loose or slushy, width of trench shall be suitably increased or side sloped or the soil shored up as directed by the Engineer-in-Charge. However, any additional excavation beyond the limit specified for firm soil herein shall not be measured for payment for excavation, backfilling, carriage, dewatering etc. item of work in the schedule of quantities as these are deemed to be included in item of work in the schedule of quantities.

iii) Where more than one pipe, cable, conduit etc, are laid, the diameter shall be reckoned as the horizontal distance from outside to outside of the outermost pipes, cable, conduit etc.

f) Where soft rock and hard rock are mixed, the measurement shall be done as follows. The two types of rock shall be stacked separately and measured in stacks. The net quantity of each type of rock shall be so arrived by applying a deduction of 50% for looseness/voids in the stacks. If the sum of net quantity of the two types of rock so arrived exceeds the total quantity of excavation, then the quantity of each type of rock shall be worked out from the total quantity (from excavation) in the ratio of net quantities in stack measurements of the two types of rock. If stacking is not feasible, the method as suggested by the engineer shall be followed.

g) Where soil, soft rock and hard rock are mixed, the measurement shall be done as follows. The soft and hard rock shall be removed from the excavated material and stacked separately and measured in stacks. The net quantity of each type of rock shall be so arrived by applying a deduction of 50% for looseness/voids in stacks. The difference between the entire excavation and the sum of the quantities of soft and hard rock so arrived shall be taken as soil.

h) The authorized quantity (calculated on the basis of authorized width/ working space under clause no. 5.2.0 c, 5.2.0 d & 5.2.0 e) or those actually excavated, whichever, are less, shall be measured for payment.

i) Tree cutting having girth more than 300mm shall be measured in number and are separately payable as deemed not covered in excavation items of work in the schedule of quantities.

j) Special dewatering of ground water by well point method and side protection work by sheet piling are separately payable as deemed not covered in excavation items of work in the schedule of quantities.

6.0.0 INFORMATION TO BE SUBMITTED BY THE BIDDER

6.1.0 With Tender

Detail of equipments and machineries proposed to be used for excavation, backfilling and compaction shall be submitted along with the tender.

6.2.0 After Award

After award of the contract the successful bidder shall submit the following for approval.

a) Within 30 days of the award of contract, the contractor shall submit a detailed programme of the work as proposed to be executed giving completion dates of excavation for the various foundations and the time required for backfilling and compaction after completion of foundation for the structures. The earthwork programme shall be planned in accordance with the foundation programme. The programme should also show how the excavation and backfilling quantities will be balanced minimizing the temporary stacking of spoils. It is to be noted that the engineer even after initial approval of the programme may instruct the contractor to enhance or to retard the progress of work during the actual execution in order to match with the progress of foundations. The initial programme being submitted by the contractor should have sufficient flexibility to take care of such reasonable variations.

b) Within 15 days of the award of contract, the contractor shall submit the drawings for earth work in excavation and backfilling showing detail of slopes, shoring, approaches, sump pits, dewatering lines, fencing etc for the approval of the engineer.

VOLUME – II B
CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

SPECIFICATION NO. PE-TS-999-600-C002

SECTION – D

SUB SECTION – D2

GENERAL TECHNICAL SPECIFICATION

CEMENT CONCRETE (PLAIN & REINFORCED)

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
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SUB-SECTION – D2

CEMENT CONCRETE (PLAIN & REINFORCED)

1.00.00 SCOPE

1.01.00 General

This specification covers all the requirements, described hereinafter for general use of Plain and Reinforced Cement Concrete work in Structures and locations, cast-in-situ or precast, and shall include all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work. Special requirements for structures such as reinforced concrete chimney, cooling towers, etc. have been covered under the respective specifications. Those specifications shall be used in conjunction with this specification.

1.02.00 IS: 456 shall form a part of this specification and shall be complied with unless permitted otherwise. For any particular aspect not covered by this Code, appropriate Code, specifications and/or replacement by any International code of practice as may be specified by the Engineer shall be followed. All codes and Standards shall conform to its latest revisions. A list of IS codes and Standards is enclosed hereinafter for reference. However, should the list be not exhaustive and does not cover any aspect of the work, then relevant Indian and, in its absence, relevant International code shall apply.

2.00.00 General

2.01.00 Work to be provided for by the Contractor

The work to be provided for by the Contractor, unless otherwise specified shall include but not be limited to the following

a) Furnish all labour, supervision, services including facilities as may be required under statutory labour regulations, materials, forms, templates, supports, scaffolds, approaches, aids, construction equipment, tools and plants, transportations, etc. required for the work.

b) Prepare Bar bending Schedules for reinforcement bars showing the positions and details of spacers, supports, chairs, hangers etc.

c) Prepare working drawings of formworks, scaffolds, supports, etc.

d) Prepare shop drawings for various inserts, anchors, anchor bolts, pipe sleeves, embedments, hangers, openings, frames etc.

e) Prepare detailed drawings of supports, templates, hangers, etc. required for

installation of various embedments like inserts, anchor bolts, pipe sleeves, frames, joint seals, frames, openings etc.

As decided by the Engineer some or all of the drawings & schedules prepared under item (b) to (e) above will have to be submitted for approval.

f) Submit for approval detailed schemes of all operations required for executing the work, e.g. material handling, Concrete mixing, Placement of concrete, Compaction, curing, services, Approaches, etc.

g) Design and submit for approval concrete mix designs required to be adopted on the job.

Furnish samples and submit for approval results of tests of various properties of the following:

i) The various ingredients of concrete

ii) Concrete

iii) Embedments

iv) Joint seals

i) Provide all incidental items not shown or specified in particular but reasonably implied or necessary for successful completion of the work in accordance with the drawings and specifications.

j) For supply of certain materials normally manufactured by specialist firms, the Contractor may have to produce, if directed by the Engineer, a guarantee in approved Performa for satisfactory performance for a reasonable period as may be specified, binding both the manufacturers and the Contractor, jointly and severally.

2.02.00 Work by others

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the contract.

2.03.00 Information to be submitted by the Tenderer

2.03.01 With Tender

The following technical information's are required with the tender:

a) Source and arrangement of processing of aggregates proposed to be adopted.

b) Type of plant and equipment proposed to be used.

c) Names of firms with which association is sought for to execute the special items of work in the contract.

d) Types of formwork proposed to be used.

2.03.02 After Award

The Contractor shall submit the following information and data including samples where necessary, progressively during the execution of the contract.

a) Programme of Execution

Within 30 days of the award of contract, the Contractor will submit a Master Programme for completion of the work.

This Master Programme may have to be reviewed and updated by the Contractor, quarterly or at more frequent intervals as may be directed by the Engineer depending on the exigencies of the work.

Detailed day-to-day Programme of every month is to be submitted by the Contractor before the end of the previous month.

b) Samples

Samples of the following materials and any other materials proposed to be used shall be submitted as directed by the Engineer, in sufficient quantities free of cost, for approval. The Engineer for future reference will preserve approved samples. The approval of the Engineer shall not, in any way, relieve the Contractor of his responsibility of supplying materials of specified qualities:

i) Coarse and fine aggregates.

ii) Admixtures.

iii) Plywood for Formwork.

iv) Embedded and anchorage materials as may be desired by the Engineer.

v) Joint sealing strips and other*waterproofing materials.

vi) Joint filling compounds.

vii) Foundation quality Rubber Pads.

c) Design Mix

Design mix as per specification giving proportions of the ingredients, sources of aggregates and cement, along with test results of trial mixes as per relevant I.S., is to be submitted to the Engineer for his approval before it can be used on the works.

d) Bar Bending Schedules

Bar Sending Schedules in accordance with Clause 2.01.00 (b) and 3.16.01 of this specification.

e) Detailed Drawings and Designs of Formworks to be used

Detailed design data and drawings of standard formworks to be used as per clause 2.01.00 (c).

f) Detailed Drawings for Templates & Temporary Supports for embedment As per Clause 2.01.00 (e).

g) Mill Test Reports for Cement & Reinforcing Steel.

h) Inspection Reports

The Engineer in accordance with Clause 2.04.00 of this specification may desire inspection Reports in respect of Formwork and Reinforcement and any other item of work as.

i) Test Reports

Reports of tests of various materials and concrete as required under Clause 4.0: SAMPLING & TESTING of this specification or as directed by the Engineer.

j) Any other data, which may be required as per this specification or as directed by the Engineer.

2.04.00 Conformity with Design

The Contractor will prepare checklists in approved Performa, which will be called "Pour Cards". These Pour Cards will list out all items of work involved. The Contractor will inform the Engineer, sufficiently in advance, whenever any particular pour is ready for concreting. He shall accord all necessary help and assistance to the Engineer for all checking required in the pour. On satisfying himself that all details are in accordance to the drawings and specifications, the engineer will give written permission on the same Pour

Cards allowing the contractor to commence placement of concrete. Details of all instructions issued by the Engineer and the records of compliance by the Contractor, deviations allowed by the Engineer and any other relevant information will be written on accompanying sheets attached to the Pour Cards. The Pour Cards along with accompaniments will be handed over to the Engineer before starting placement of concrete. One of the mix designs developed by the Contractor as per the I.S. Specifications and established to the satisfaction of the Engineer by trial mixes shall be permitted to be used by the Engineer, the choice being dictated by the requirements of designs and workability. The methods of mixing, conveyance, placement, vibration, finishing, curing, protection and testing of concrete will be as approved or directed by the Engineer.

2.05.00 Materials to be used

2.05.01 General Requirement

All materials whether to be incorporated in the work or used temporarily for the construction shall conform to the relevant IS Specifications unless-stated otherwise and be of best approved quality.

2.05.02 Cement

Ordinary Portland cement of grade-43 as per IS:8112/fly ash based Portland puzzolona cement conforming to IS:1489 (Part-1) shall preferably be used in reinforced/plain cement concrete works for all areas other than for the critical structures identified below. However, other types of cement such as ordinary Portland cement conforming to IS:269, Portland slag cement conforming to IS:455 respectively can be used under special circumstances. Cement used in all concrete mixes shall be in general of grade 33/43 unless design requires a higher grade. Ordinary Portland cement shall be used for following structure.

a) TG foundation top deck and sub structures including raft.

b) Spring Supporting decks of all machine foundations.

c) Structures requiring grade of concrete of M30 and above.

In special cases, Rapid Hardening Portland Cement, Low Heat Cement, Sulphate resistant cement, high strength Ordinary Portland Cement etc. may be permitted or directed to be used by the Engineer.
For Brickwork, plaster, flooring and other finishing works, ordinary Portland cement of 33/43 grade shall be used.

2.05.03 Coarse Aggregate

Aggregate of sizes ranging between 4.75 mm and 150 mm will be termed as

Coarse Aggregate. Coarse aggregate for concrete shall be chemically inert, hard, strong durable against weathering, of limited porosity, and free from deleterious materials. It shall be properly graded. Coarse aggregates shall be either crushed gravel or stone. All aggregates shall meet the requirement of IS:383:1970. Only Coarse Aggregate from, approved quarries and conforming to IS-383 will be allowed to be used on the works. Petrographic test shall be carried out by the contractor free of cost for checking the quality of rock from quarry. This test shall be repeated by the Contractor free of cost for change in quarry or as directed by the Engineer. The results shall be checked for reactivity of silica in aggregate with alkalis of cement.

2.05.04 Fine Aggregate

Aggregate smaller than 4.75 mm and within the grading limits and other requirements set in IS: 383 are termed as Fine Aggregate or Sand. Only Fine Aggregate from approved sources and conforming to the above IS Specification will be allowed to be used in works. Sand shall be hard, durable, clean and free from adherent coatings or organic matter and clay balls or pellets. Sand when used as fine aggregate in concrete shall conform to IS:383. For plaster, it shall conform to IS:1542 and for masonry work to IS:2116.

2.05.05 Water

Water for use in Concrete shall be clear and free from injurious oils, acids, alkalis, organic matter, salt, silts, or other impurities. Generally, IS: 3550 will be followed for routine tests. Acceptance of water shall be as per IS: 456.

2.05.06 Admixture

Only admixtures of approved quality will be used when directed or permitted by the Engineer. The different types of admixtures, which may be necessary to satisfy the concrete mix and the design requirement, shall be as per IS-9103 and may be one of the followings:

a) Accelerating admixture

b) Retarding admixture

c) Water reducing admixture

d) Air entraining admixture

e) Water proofing admixture

The contractor shall inform the Engineer about the type of admixture which he is planning to use in different areas within the scope of work for the approval

of the Engineer. The admixture shall be of proven make and from a reputed manufacturer. It should not have any adverse effect on strength, durability of concrete and reinforcement. Super plasticizers conforming to IS: 9103 or ASTMC-494 shall only be used as admixture having the above properties either individually or in a combination as per the direction of the Engineer.

2.05.07 Reinforcement

Reinforcement shall be as per relevant IS Specification as mentioned in the Contract/Drawing/Instructions. All bars shall be of tested quality.

2.06.00 Storage of Materials

2.06.01 General

All materials shall be stored so as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material, which has deteriorated or has been damaged or is otherwise considered defective by the Engineer, shall not be used for concrete and shall be removed from site immediately, failing which, the Engineer shall be at liberty to get the materials removed and the cost incurred thereof shall be realised from the Contractor's dues. The Contractor shall maintain upto-date accounts of receipt, issue and balance (stack wise) of all materials. Storage of materials shall conform to IS: 4082.

2.06.02 Cement

Sufficient space for storage, with open passages between stacks, shall be arranged by the Contractor to the satisfaction of the Engineer.

Cement shall be stored off the ground in dry, leak proof, well-ventilated warehouses at the works in such a manner as to prevent deterioration due to moisture or intrusion of foreign matter.

Cement shall be stored in easily countable stacks with consignment identification marks. Consignments shall be used in the order of their receipts at site. Sub-standard or partly set cement shall not be used and shall be removed from the site, with the knowledge of the Engineer, as soon as it is detected.

2.06.03 Aggregates

Aggregates shall be stored on raised surface constructed by providing planks or steel plates or on concrete or brick masonry pavement. Each size shall be kept separated with wooden or steel or concrete or masonry bulkheads or in separate stacks and sufficient care shall be taken to prevent the material at the

edges of the stock piles from getting intermixed. Stacks of fine and coarse aggregates shall be kept sufficiently apart with proper arrangement of drainage. The aggregates shall be stored in easily measurable stacks of suitable depths as may be directed by the Engineer.

2.06.04 Reinforcement

Reinforcing steel shall be stored consignment-wise and size-wise off the ground and under cover, if desired by the Engineer. It shall be protected from rusting, oil, grease, and distortions.

If necessary, the reinforcing steel may be coated with cement wash before stacking to prevent scale and rust at no extra cost to the Owner. The stacks shall be easily measurable. Steel needed for immediate use shall only be removed from storage.

2.07.00 Quality Control

Contractor shall establish and maintain quality control for different items of work and materials as may be directed by the Engineer to assure compliance with contract requirements and maintain and submit to the Engineer records of the same. The quality control operation shall include but not be limited to the following items of work:

a) Admixture:	Type, quantity, physical, and chemical properties that affects strength, workability, and durability of concrete. For air entraining admixtures, dosage to be adjusted to maintain air contents within desirable limits.
b) Aggregate:	Physical, chemical and mineralogical qualities. Grading, moisture content and impurities.
c) Water:	Impurities tests.
d) Cement:	Tests to satisfy relevant IS Specifications.
e) Formwork:	Material, shapes, dimensions, lines, elevations, surface finish, adequacy of form, ties, bracing and shoring and coating.
f) Reinforcement:	Shapes, dimensions, length of splices, clearances, ties and supports. Quality and requirement of welded splices.

		Material tests or Certificates to satisfy relevant IS Specification.
	g) Grades of Concrete:	Usage and mix design, testing of all properties.
	h) Batching & Mixing:	Types and capacity of plant, concrete mixers and transportation equipment.
	i) Joints:	Locations of joints, water stops and filler materials. Dimension of joints, quality, and shape of joint material and splices.
	j) Embedded and Anchorage Items:	Material, shape, location, setting.
	k) Placing:	Preparation, rate of pouring, weather limitations, time intervals between mixing and placing and between two successive lifts, covering over dry or wet surfaces, cleaning and preparation of surfaces on which concrete is to be placed, application of mortar/slurry for proper bond, prevention of cold joint, types of chutes or conveyors.
	l) Compaction:	Number of vibrators, their prime mover, frequency and amplitude of vibration, diameter and weight of vibrators, duration of vibration, hand-spreading, rodding and tamping.
	m) Setting of base & Bearing plates:	Lines, elevations, and bedding mortar.
	n) Concrete Finishes:	Repairs of surface defects, screening, floating, steel trowelling and brooming, special finishes.
	o) Curing:	Methods and length of time.

Copies of records and tests for the items noted above, as well as, records of corrective action taken shall be submitted to the Engineer for approval as may be desired.

3.00.00 INSTALLATION

All installation requirements shall be in accordance with IS: 456 and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification do not

cover all the aspects to the full satisfaction of the Engineer.

3.01.00 Washing and Screening of Aggregates

Washing and screening of coarse and fine aggregates to remove fines, dirt, or other deleterious materials shall be carried out by approved means as desired by the Engineer.

3.02.00 Admixture

All concrete shall be designed for normal rate of setting and hardening at normal temperature. Variations in temperature and humidity under different climatic conditions will affect the rate of setting and hardening, which will, in turn, affect the workability and quality of the concrete. Admixtures including plasticisers of approved make may be used with the Engineer's approval in accordance with IS-456 to modify the rate of hardening, to improve workability or as an aid to control concrete quality. The Engineer reserves the right to require laboratory test or use test data, or owner satisfactory reference before granting approval. The admixture shall be used strictly in accordance with the manufacturer's directions and/or as directed by the Engineer.

3.03.00 Grades of Concrete

Concrete shall be in one of the grades designated in IS: 456. Grade of concrete to be used in different parts of work shall be as shown on the drawing. In case of liquid retaining structures, IS: 3370 will be followed. Minimum cement content shall be as per IS: 456.

3.04.00 Proportioning and Works Control

3.04.01 General

"Design Mix Concrete" and "Nominal Mix Design" is defined as follows for use in this specification:

a) Proportioning of ingredients of concrete made with preliminary tests by designing the concrete mix. Such concrete shall be called "Design Mix Concrete".

b) Proportioning of ingredients of concrete made without preliminary tests adopting nominal concrete mix. Such concrete shall be called "Nominal Mix Concrete".

As far as possible, design mix concrete shall be used on all concrete works. Nominal mix concrete, in grades M-15 or lower only may be used if shown on drawings or approved by the Engineer. In all cases the Proportioning of ingredients and works control shall be in accordance with IS: 456 and shall be

adopted for use after the Engineer is satisfied regarding its adequacy and after obtaining his approval in writing.

3.04.02 Mix Design Criteria

Concrete mixes will be designed by the Contractor to achieve the strength, durability, and workability necessary for the job, by the most economical use of the various ingredients. In general, the design will keep in view the following considerations

a) Consistent with the various other requirements of the mix, the quantity of water should be kept at the lowest possible level.

b) The nominal maximum size of coarse aggregate shall be as large as possible within the limits specified.

c) The various fractions of coarse and fine aggregates should be mixed in such a proportion as to produce the best possible combined internal grading giving the densest and most workable mix.

d) The finished concrete should have adequate durability in all condition, to withstand satisfactorily the weather and other destruction agencies, which it is expected to be subjected to in actual service.

e) The mix design shall have required workability and characteristic strength as per IS: 456. The quantity of cement, aggregates, and admixtures shall be determined by mass.

The requirement of adequate structural strength is catered for by the choice of proper grade of concrete in structural design. The Contractor will strictly abide by the same in his design of concrete mix installation. Various trials shall be given by the contractor with specific cement content on each trial. In some cases, plasticizers and other admixtures may be necessary to achieve the desired results.

3.05.00 Strength Requirements

The strength requirements of both design mix and nominal mix concrete where ordinary Portland Cement or Portland Blast furnace slag cement is used, shall be as per IS:456. All other relevant clauses of IS:456 shall also apply.

3.06.00 Minimum Cement Content

The minimum cement content for each grade of concrete shall be as per IS: 456. Contractor has to consider actual environmental exposure condition at

site. Based on various tests results and as per Engineer, the environment condition shall be adopted for which minimum cement content shall be considered. No extra payment shall be made on account of any variation in environment condition.

a) Sufficient number of trial mixes (to be decided by the Engineer) will be taken at the laboratory for the various designs and graphs of w/c ratio Vs crushing strengths at various ages will be plotted.

b) All tests will be done in presence of the Engineer who shall be the final authority to decide upon the adoption of any revised minimum cement content. The Contractor will always be responsible to produce quality concrete of the required grade as per the acceptance criteria of IS: 456.

c) The Engineer will always have the unquestionable right to revise the minimum cement content as decided above, if, in his opinion, there is any chance of deterioration of quality on account of use of lower cement content or any other reason.

3.07.00 Water-Cement Ratio

The choice of water-cement ratio in designing a concrete mix will depend on:-

a) The requirement of strength.

b) The requirement of durability.

3.07.01 Strength Requirement

In case of "Design Mix Concrete" the water-cement ratio of such value as to give acceptable test results as per IS: 456, will be selected by trial and error. The values of water-cement ratios for different grade and mix designs will have to be established after conducting sufficiently large number of preliminary tests in the laboratory to the satisfaction of the Engineer. Frequent checks on test will have to be carried out and the water-cement ratios will be revised if the tests produce unsatisfactory results. Notwithstanding anything stated above the Contractor's responsibility to produce satisfactory test results and to bear all the consequences in case of default remains unaltered.

In case of nominal mix concrete, the maximum water-cement ratio for different grades of concrete is specified in Table-5 of IS: 456 and no tests are necessary. The acceptance test criterion for nominal mix concrete shall be as per IS: 456.

3.07.02 Durability Requirement

Tables 4 & 5 of IS: 456 give the maximum water-cement ratio permissible from the point of view of durability of concrete subjected to adverse exposure to weather, sulphate attacks, and contact with harmful chemicals. Impermeability may also be an important consideration.

Whenever the water-cement ratio dictated by Durability consideration is lower than that required from strength criteria, the former should be adopted.

In general the water cement ratio between 0.4 and 0.45 will be desirable to satisfy the durability requirement and from the consideration of impermeability of concrete. The contractor may propose lower water cement ratio as mentioned above by addition of a suitable plasticizer/super-plasticizer. Trial mix shall be carried out accordingly. However, the contractor has to propose specifically along with field trials in the event of lower cement content if found suitable along with a plasticizer.

3.08.00 Workability

The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of formwork and around the reinforcement and embedments and to give the required surface finish shall depend*on the type and nature of structure and shall be based on experience and tests. The usual limits of consistency for various types of structures are given below:

TABLE-V

LIMITS OF CONSISTENCY

Degree of	Slump in mm with Standard Cone as	Use for which concrete is suitable

workability	per IS: 1199		
	Min.	Max.	
Very low	0	25	Large Mass concrete structure with heavy compaction equipments, roads
Low	25	50	Uncongested wide and shallow R.C.C. structures
Medium	50	100	Deep but wide R.C.C. structures with congestion of reinforcement and inserts
High	100	150	Very narrow and deep R.C.C. structures with congestion due to reinforcement and inserts.

Note: Notwithstanding anything mentioned above, the slump to be obtained for work in progress shall be as per direction of the Engineer.

With the permission of the Engineer, for any grade of concrete, if the water has to be increased in special cases, cement shall also be increased proportionately to keep the ratio of water to cement same as adopted in trial mix design for each grade of concrete. No extra payment will be made for this additional cement.

The workability of concrete shall be checked at frequent intervals by slump tests.

3.09.00 Size of coarse Aggregates

The maximum size of coarse aggregates for different locations shall be as follows unless otherwise directed by the Engineer

Very narrow space	- 12 mm
Reinforced concrete Except foundation	- 20 mm
Ordinary Plain concrete and Reinforced concrete foundations	- 40 mm
Mass concrete	- 80 mm

Lean concrete - 40 mm

Grading of coarse aggregates for a particular size shall conform to relevant I.S. Codes and shall also be such as to produce a dense concrete of the specified proportions, strength and consistency that will work readily into position without segregation.

Coarse aggregate will normally be separated into the following sizes and stacked separately in properly designed stockpiles

80 mm to 40 mm, 40 mm to 20 mm and 20 mm to 5 mm. In certain cases it may be necessary to further split the 20 mm to 5 mm fraction into 20 mm to 10 mm and 10 mm to 5 mm fractions.

This separation of aggregates in different size fractions is necessary so that they may be remixed in the desired proportion to arrive at a correct internal grading to produce the best mix.

3.09.01 Temperature control of concrete in top decks of machine foundations (i.e. of TGs, BFPs, Fans and Mills) as extra payable over RCC item of BOQ:

The temperature of fresh concrete shall not exceed 23°C when placed. A suitable measuring device for measuring the temperature of concrete as approved by the Engineer shall be used. For maintaining the limiting temperature of the 23°C, crushed ice shall be used as mixing water. The ice shall be formed of water conforming IS: 456. The Contractor shall establish the quantity of crushed ice to be mixed in order to achieve the limiting temperature of 23°C.

3.09.02 Base raft of Turbo Generator foundations and top decks of all machine foundations shall be cast in a continuous operation without any construction joint.

3.10.00 Mixing of Concrete

Ingredients of the concrete mix shall be measured by weight. Concrete shall always be mixed in mechanical mixer. Water shall not normally be charged into the drum of the mixer until all the cement and aggregates constituting the batch are already in the drum and mixed for at least one minute. Mixing of each batch shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency, but in no case shall mixing be done for less than 2 (two) minutes and at least 40 (forty) revolutions after all the materials and water are in the drum. When absorbent Aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Engineer. Mixers shall not be loaded above their rated capacity as this prevents thorough mixing.

The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used. Such concrete shall be immediately removed from site. Each time the work stops, the mixer shall be thoroughly cleaned & when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Owner to allow for loss in the drum.

Regular checks on mixer efficiency shall be carried out as directed by the Engineer as per IS: 4634 on all mixers employed at site only those mixers whose efficiencies are within the tolerances specified in IS: 1791 will be allowed to be employed.

Batching Plant shall conform to IS: 4925. The measuring gauges of batching plant shall be periodically calibrated for which the contractor shall provide standard weights. The accuracy of all gauges shall be within limits prescribed by the Engineer.

When hand mixing is permitted by the Engineer, for unimportant out of the way locations in small quantities, it shall be carried out on a water-tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. In case of hand-mixing, 10% extra cement shall be added to each batch at no extra cost to the owner.

3.11.00 Conveying Concrete

Concrete shall be handled and conveyed from the place of mixing to the place of laying as rapidly as practicable by approved means and placed and compacted in the final position before the initial setting of the cement starts. Concrete should be conveyed in such a way as will prevent segregation or loss of any of the ingredients. For long distance haulage, agitator cars of approved design will be used. If, in-spite of all precautions, segregations does occur during transport, the concrete shall be properly re-mixed before placement. During very hot or cold weather, if directed by the Engineer, concrete shall be transported in deep containers, which will reduce the rate of loss of water, by evaporation or loss of heat. If necessary, the container may have to be covered and insulated. Conveying equipments for concrete shall be well maintained and thoroughly cleaned before, commencement of concrete mixing. Such equipments shall be kept free from set concrete.

3.12.00 Placing and Compacting Concrete

Where specifically covered, the relevant I.S. Code will be followed for the procedure of surface preparation, placement, consolidation, curing, finishes, repairs and maintenance of concrete. If, however, there is no specific provision in relevant I.S. code for any particular aspect of work, any other standard code of practice, as may be specified by the Engineer, will be

adopted. Concrete may have to be placed against the following types of surfaces:

a) Earth foundation

b) Rock foundation

c) Formwork

d) Construction joint in concrete or masonry

The surface on or against which concrete is to be placed has to be cleaned thoroughly. Rock or old construction joint has to be roughened by wire brushing, chipping, sand blasting or any other approved means for proper bond. All cuttings, dirt, oil, foreign and deleterious material, laitance, etc. are to be removed by air water jetting or water at high pressure. Earth foundation on which direct placement of concrete is allowed, will be consolidated as directed by the Engineer such that it does not crumble and get mixed up with the concrete during or after placement, before it has sufficiently set and hardened.

Formwork, reinforcement, preparation of surface, embedments, joint seals etc., shall be approved in writing by the Engineer before concrete is placed. As far as possible, concrete shall be placed in the formwork by means approved by the Engineer and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1500 mm shall have to be approved by the Engineer.

Rock foundation or construction joint will be kept moist for at least 72 hours prior to placement. Concrete will be placed always against moist surface but never on pools of water. In case the foundation cannot be dewatered completely, special procedure and precaution, as directed by the Engineer will have to be adopted.

Formwork will be cleaned thoroughly and smeared lightly with form oil or grease of approved quality just prior to placement.

A layer of mortar of thickness 12 mm of the same or less w/c ratio and the same proportion as that of the concrete being placed or cement slurry will be spread thoroughly on the rock Foundation or construction joint just prior to placement of concrete.

After concrete has been placed, it shall be spread, if necessary & thoroughly compacted by approved mechanical vibration to maximum, subsidence without segregation and thoroughly worked around shape. Vibrators shall not be used for pushing concrete into adjoining areas. Vibrators must be operated by experienced workmen and the work carried out as per relevant IS Code of

Practice: In thin members with heavy congestion of reinforcement or other embedments, where effective use of internal vibrator is, in the opinion of the Engineer, doubtful, in addition to immersion vibrators the contractor may have to employ form vibrators conforming to IS: 4656. For slabs and other similar structures, the contractor will additionally employ screed vibrator as per IS: 2506. Hand tamping may be allowed in rare cases, subject to the approval of the Engineer. Care must be taken to ensure that the inserts, fixtures, reinforcement, and formwork are not displaced or distorted during placing & consolidation of concrete.

The rate of placement of concrete shall be such that no cold joint is formed and fresh concrete is placed always against green Concrete, which is still plastic and workable. No concrete shall be placed in open, during rains. During rainy season, no placement in the open is to be attempted unless sufficient tarpaulins or other similar protective arrangement for completely covering the still green concrete from rain is kept at the site of placement. If there has been any sign of washing of cement and sand, the entire affected concrete shall be removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete.

Slabs, beams, and similar members shall be poured in one operation, unless otherwise instructed by the Engineer. Mouldings, throating, drip course, etc., shall be poured as shown on the drawings or as directed by the Engineer. Holes shall be provided and bolts, sleeves, anchors, fastenings, or other fixtures shall be embedded in concrete as shown on the drawings or as directed by the Engineer. Any deviation there from shall be set right by the Contractor at his own expense as instructed by the Engineer.

In case the forms or supports get displaced during or immediately after the placement and bring the concrete surface out of alignment beyond tolerance limits, the Engineer may direct to remove the portion and reconstruct or repair the same -at the Contractor's expense.

The Engineer shall decide upon the time interval between two placements of concrete of different ages coming in contact with each other, taking in consideration the degree of maturity of the older concrete, shrinkage, heat dissipation and the ability of the older concrete to withstand the load imposed upon it by the fresh placement.

Once the concrete is deposited, consolidated and finished in its final position, it shall not be distributed.

3.13.00 Construction Joints and Cold Joints

3.13.01 Construction Joints

It is always desirable to complete any concrete structure by continuous pouring in one operation. However, due to practical limitation of methods and equipment and certain design considerations, construction joints are formed by discontinuing concrete certain predetermined stages. These joints will be formed in a manner specified in the drawings/Instruction.

Vertical construction joints will be made with rigid stop-board forms having slots for allowing passage of reinforcement rods and any other embedments and fixtures that may be shown. Next stage concrete shall be placed against construction joint as per clause 3.12.

Where the location of the joints are not specified, it will be in accordance with the following:

a) In a column, the joint shall be formed 75 mm below the lowest soffit of the beam framing into it.

b) Concrete in a beam shall preferably be placed without a joint, but if Provision of a joint is unavoidable, the joint shall be vertical and at the middle of the span.

c) A joint in a suspended floor slab shall be vertical and at the middle of the span and at right angles to the principal reinforcement.

d) Feather-edges in concrete shall be avoided while forming a joint.

e) A construction joint should preferably be placed in a low-stress zone and at right angles to the direction of the principal stress.

f) In case the Contractor proposes to have a construction joint anywhere to facilitate his work, the proposal should be submitted well in advance to the Engineer for study and approval without which no construction joint will be allowed.

3.13.02 Cold Joint

An advancing face of a concrete pour, which could not be covered by fresh concrete before expiry of initial setting time (due to an unscheduled stoppage or delay on account of breakdown in plant, inclement weather, low rate of placement or any other reason), is called a cold joint. The Contractor should always remain vigilant to avoid cold joints.

If, however, a cold joint is formed due to unavoidable reasons, the following procedure shall be adopted for treating it:

a) If the concrete is so green that it can be removed manually and if vibrators

can penetrate the surface without much effort, fresh concrete can be placed directly against the old surface. The old concrete should be covered by fresh concrete as quickly as possible and the joint thoroughly and systematically vibrated.

b) In case concrete has hardened a bit more than (a) but can still be easily removed by a light hand pick, the surface will be raked thoroughly and the loose concrete removed completely without disturbing the rest of the concrete in depth. A rich mortar layer 12 *mm* in thickness, will be placed on the cold joint fresh concrete shall be placed on the mortar layer and the joint will be thoroughly and systematically vibrated penetrating the vibrator deep into the old layer of concrete.

c) In case the concrete at the joint has become so stiff that it cannot be remoulded and mortar or slurry does not raise inspite of extensive vibration, the joint, will be left to harden for at least 12 - 24 hrs. It Will then be treated as a regular construction joint, after cutting the concrete to required shape and preparing the surface as described under clause 3.12.

3.14.00 Repairs, Finishes, and Treatment of Concrete surfaces

3.14.01 Adequate and sound concrete surfaces, whether formed or unformed, can be obtained by employing a concrete mix of proper design, competent formwork, appropriate methods of handling, placing, and consolidation by experienced workmen.

Unsound concrete resulting from improper mix design, incompetent methods, equipment and formwork, poor workmanship and protection will not be accepted and will have to be dismantled, removed and replaced by sound concrete at the Contractor's cost. The Engineer may, at his sole discretion, allow to retain concrete with minor defects provided the Contractor is able to repair it by approved methods at no extra cost to the Owner, All concrete work shall be inspected by the Contractor immediately after the forms are removed & he will promptly report occurrence of any defects to the Engineer. All repair works will be carried out as per the instructions and in the presence of the Engineer or his representative. Generally, repair work will consist of any or all of the following operations:

a) Sack rubbing with mortar and stoning with carborundum stone.

b) Cutting away the defective concrete to the required depth shape.

c) Cleaning of reinforcement & embedments. It may be necessary to provide an anti-corrosive coating on the reinforcement.

d) Roughening by sand blasting or chipping.

e) Installing additional reinforcement/welded mesh fabric.

f) Dry packing with stiff mortar.

g) Plastering, guniting, shotcreting etc.

h) Placing and compacting concrete in the void left by cutting out defective concrete.

i) Grouting with cement sand slurry of 1:1 mix.

j) Repairing with a suitable mortar either cement or resin modified mortars.

k) Polymer modified patching and adhesive repair& mortar for beams & columns.

3.14.02 Finishing unformed Surface

The contractor shall provide normal finishes in unformed surfaces which can be achieved by screeding, floating, trowelling etc. A few typical and common cases of treatment of concrete surface are cited below

a) Floor

Whenever a non-integral floor finish is indicated, the surface of reinforced concrete slab shall be struck off at the specified levels and slopes and shall be finished with a wooden float fairly smooth removing all laitance. No over trowelling, to obtain a very smooth surface, shall be done, as it will prevent adequate bond with the subsequent finish. If desired by the Engineer, the surface shall be scored and marked to provide better bond.

Where monolithic finish is specified or required, concrete shall be compacted and struck off at the specified levels and slopes with a screed, preferably a vibrating type and then floated with a wooden float. Steel trowelling is then started after the moisture film and shine have disappeared from the surface and after the concrete has hardened enough to prevent excess of fines and water to rise to the surface but not hard enough to prevent proper finishing of aberrations. Steel trowelling properly done will flatten and smoothen sandy surface left by wooden floats and produce a dense surface free from blemishes, ripples, and trowel marks.

A fine textured surface that is not slick and can be used where there is likelihood of spillage of oil or water can be obtained by trowelling the surface lightly with a circular motion after initial trowelling keeping the steel trowel flat on the surface.

To provide a better grip the Engineer may instruct marking the floor in a regular geometric pattern after initial trowelling.

b) Beans, Columns & Walls

If on such or any other concrete structure it is intended to apply plaster or such concrete surfaces against which brickwork or other allied works are to be built, the Contractor shall hack the surface adequately as soon as the form is stripped off so that proper bond can develop. Pattern, adequacy, and details of such hacking shall meet with the approval of the Engineer, who shall be informed to inspect such surfaces before they are covered up.

3.15.00 Protection and Curing of concrete

Newly placed concrete shall be protected by approved means from rain, sun, and wind. Concrete placed below the ground level shall be protected against contamination from falling earth during and after placing. Concrete placed in ground containing deleterious substances, shall be protected from contact with such ground, or with water draining from such ground, during placing of concrete and for a period of at least three days, or as otherwise instructed by the Engineer. The ground water around newly poured concrete shall be kept to an approved level by pumping out or other adequate means of drainage to prevent floatation or flooding. Steps, as approved by the Engineer, shall be taken to protect immature concrete from damage by debris, excessive 'Loadings, vibration, abrasion, mixing with earth or other deleterious materials, etc. that may impair the strength and durability of the concrete.

As soon as the concrete has hardened sufficiently, it shall be covered either with sand, hessian, canvas, or similar materials and kept continuously wet for at least 14 (fourteen) days after final setting. Curing by continuous sprinkling of water will be allowed if the Engineer is satisfied with the adequacy of the arrangements made by the Contractor. Quality of water for curing shall be as per IS: 456.

If permitted by the Engineer, liquid curing compound may be used for prevention of premature water loss in concrete and thereby effecting curing of concrete. This type of curing compound shall be sprayed on newly laid concrete surfaces to form a thin film barrier against premature water loss without disturbances to normal setting action. The curing compound shall be emulsified paraffin based and shall comply with ASTM requirements for acceptance.

The curing compound shall be applied following the final finishing operation and immediately after disappearance of water from concrete surface. It is important not to apply the curing compound when standing water is still present on concrete.

The contractor shall arrange for the manufacturer's supervision at no extra cost.

The Contractor shall remain extremely vigilant and employ proper equipment and workmen under able supervision for curing. The Engineer's decision regarding the adequacy of curing is final. In case the Engineer notices any lapse on the part of the Contractor, he will inform the Contractor or his supervisor verbally or in writing to correct the deficiency in curing. If no satisfactory action is taken by the Contractor within 3 (three) hours of issuance of such instruction, the Engineer will be at liberty either to employ sufficient means through any agency to make good the deficiency and recover the cost thereof from the Contractor, or deduct certain amount from contractor's payment for the part where inadequate curing was noticed entirely at the discretion of the Engineer.

3.16.00 Reinforcement

Mild steel round bars, TMT bars, Hot rolled deformed bars or cold twisted deformed bars as medium tensile or high yield strength steel, plain hard drawn steel wire fabric etc, will be used as reinforcement as per drawings and directions. In an aggressive environment an anti-corrosive coating on the reinforcement may be provided as per IS: 9077, as shown on the drawing or as directed by the Engineer.

3.16.01 Bar Bending Schedules

The Contractor shall prepare Bar Bending Schedules showing clearly the arrangements proposed by the Contractor to match available stock of reinforcing steel, progressively, starting within one week of receipt of approval on corresponding design of RCC structure. As decided by the Engineer, some or all the detailed drawings and schedules will have to be submitted for approval. Approval of such detailed drawings by the Engineer shall not relieve the Contractor of his responsibility for correctness nor of any of his obligations to meet the other requirements of the contract. The contractor for record and distribution shall submit six prints of the final drawings & schedules with one reproducible print.

3.16.02 Cleaning

All steel for reinforcement shall be free from loose scales, oil, grease, paint or other harmful matters immediately before placing the concrete.

3.16.03 Bending

Unless otherwise specified, reinforcing steel shall be bent in accordance with the procedure specified in IS: 2502 or as approved by the Engineer. Bends and shapes shall comply strictly with the dimensions corresponding with the

final Bar Bending Schedules. Bar Bending Schedules shall be rechecked by the Contractor before any cutting, bending is done.

No reinforcement shall be bent when already in position in the work, without approval of the Engineer, whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that will injure the material. Rebending can be done only if approved by the Engineer. Reinforcing bars shall be bent by machine or other approved means producing a gradual and even motion. All the bars shall be cold bent unless otherwise approved. Bending hot at a cherry-red heat (not exceeding 845°C) may be allowed under very exceptional circumstances except for bars whose strength depends on cold working. Bars bent hot shall not be cooled by quenching.

3.16.04 Placing in Position

All reinforcements shall be accurately fixed and maintained in position as shown on the drawings by such approved and adequate means like mild steel chairs and/or concrete spacer blocks. Bars intended to be in contact at crossing points, shall be securely tied together at all such points by No. 20 G annealed soft iron wire or by tack welding in case of Bar larger than 25 mm dia., as may be directed by the Engineer. Binders shall tightly embrace the bars with which they are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They should be spaced such that the main bars do not sag perceptibly between adjacent spacers. Before actual placing, the Contractor shall study the drawings thoroughly and inform the Engineer in case he feels that placement of certain bars is not possible due to congestion. In such cases he should not start placing any bar before obtaining clearance from the Engineer.

3.16.05 Welding / Coupler for Splicing

Lapping shall normally do splicing of reinforcement. For M.S. reinforcement bars, butt-welding may be done, if permitted by the Engineer, under certain conditions. The work should be done with suitable safeguards in accordance with relevant Indian Standards for welding of mild steel bars used in reinforced concrete construction as per IS: 2751 and IS: 456. For High yield strength deformed bars, lap welding may be done, if permitted by the Engineer, under certain conditions. The work should be done with suitable safeguards in accordance with relevant Indian Standards as per IS: 9417. Welding of High yield strength deformed bar shall not be allowed.

Splicing of reinforcement using mechanical coupler may be done, if permitted by the Engineer, under certain conditions. The work should be done with suitable safeguards in accordance with relevant Indian standards for “Reinforcement couplers for mechanical splices of bars in concrete” as per IS: 16172. Corrosion test in the coupler-bar connections exposed to marine or

severe environmental conditions to rule out any risk of galvanic corrosion will be done by the contractor at no extra cost. Proper fitting & fixing of mechanical coupler to rebar shall be ensured at site for each coupled joint as per inspection testing plan developed at site in consultation with manufacturer of coupler. If so required at site, coupler/ threading on rebar shall be such that two bars can be coupled by moving couplers not rebar (as being heavy reinforcement weight and L shaped, it is not feasible to rotate the rebar for fixing up the coupler) at no extra cost.

3.16.06 Control

The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be examined by the Engineer for accuracy of placement and cleanliness. Necessary corrections as directed by him shall be carried out. Laps and anchorage lengths of reinforcing bars shall be in accordance with IS: 456, unless otherwise specified. The laps shall be staggered as far as practicable and as directed by the Engineer. Arrangements for placing concrete shall be such that reinforcement in position does not have to bear extra load and get disturbed. The cover for concrete over the reinforcements shall be as shown on the approved drawings unless otherwise directed by the Engineer. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar not leaner than 1 (one) part cement to 2 (two) parts sand by –volume and cured in a pond for at least 14 (fourteen) days. The type, shape, size and location of the concrete blocks shall be as approved by the Engineer.

3.17.00 Cold Weather Concreting

When conditions are such that the ambient temperature may be expected to be 5°C or below during the placing and curing period, the work shall conform to the requirement of IS: 456 and IS: 7861.

3.18.00 Hot Weather Concreting

When depositing concrete in very hot weather, the Contractor shall take all precautions as per IS: 7861 and stagger the work to the cooler parts of the day to ensure that the temperature of wet concrete used in massive structures does not exceed 38°C while placing. Positive temperature control by precooling, post cooling or any other method, if required, will have to be done by the contractor at no extra cost.

3.19.00 Concreting under water

When it is necessary to deposit concrete under water it shall be done in accordance with the requirements of IS: 456.

3.20.00 Form Work

3.20.01 General

If it is so desired by the Engineer, the contractor shall prepare, before commencement of actual work, designs and working drawings for formwork and centring and get them approved by the Engineer. The formwork shall conform to the shape, grade, lines, levels and dimensions as shown on the drawings.

Materials used for the formwork inclusive of the supports and centring shall be capable of withstanding the working load and remain undistorted throughout the period it is left in service. All supports and scaffolds should be manufactured from structural or tubular steel except when specifically permitted otherwise by the Engineer.

The centring shall be true to vertical, rigid and thoroughly braced both horizontally and diagonally. Rakers are to be used where forms are to support inclined members. The forms shall be sufficiently strong to carry without undue deformation, the dead weight and horizontal pressure of the concrete as a liquid as well as the working load. In case the contractor wishes to adopt any other design criteria, he has to convince the Engineer about its acceptability before adopting it. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration without appreciable deflection, bulging, distortion or loosening of its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of slurry or mortar.

To achieve the desired rigidity, tie bolts, spacer blocks, tie wires and clamps as approved by the Engineer shall be used but they must in no way impair the strength of concrete or cause stains or marks on the finished surface. Where there are chances of these fixtures being embedded, only mild steel and concrete of adequate strength shall be used. Bolts passing completely through liquid retaining walls/slabs for the purpose of securing and aligning the formwork shall not be used.

The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of the Engineer immediately and rectified as directed by him.

For exposed interior and exterior concrete surfaces of beams, columns and wall, plywood or other approved form shall be thoroughly cleaned and tied together with approved corrosion-resistant devices. Rigid care shall be exercised in ensuring that all column forms are in true plumb and thoroughly cross-braced to keep them so. All floor and beam centring shall be crowned

not less than 8 mm in all directions for every 5 metres span. The formwork should lap and be secured sufficiently at the lift joints to prevent bulges and offsets.

Temporary openings for cleaning, inspection and for pouring concrete shall be provided at the base vertical forms and at other places, where they are necessary and as may be directed by the Engineer. The temporary openings shall be so formed that they can be conveniently closed when required, during pouring operations without leaving any mark on the concrete.

3.20.02 Cleaning and Treatment of Forms

All parts of the forms shall be thoroughly cleaned of old concrete, wood shavings, saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish, loose concrete, chippings, shavings, sawdust etc. shall be scrupulously removed from the interior of the forms before concrete is poured. Compressed air jet and/or water jet along with wire brushes brooms etc. shall be used for cleaning. The inside surface of the formwork shall be treated with approved non-staining oil or other compound before it is placed in position. Care shall be taken that oil or other compound does not come in contact with reinforcing steel or construction joint surfaces. They shall not be allowed to accumulate at the bottom of the formwork. The oiling of the formwork will be inspected just prior to placement of concrete and redone wherever necessary.

3.20.03 Design

The formwork shall be so designed and erected that the forms for slabs and the sides of beams, columns, and walls are independent of the soffits of beams and can be removed without any strain to the concrete already placed or affecting the remaining formwork.

Removing any props or repropping shall not be done except with the specific approval of the Engineer. If formwork for column is erected for the full height of the column, one side shall be left open and built up in sections, as placing of concrete progress. Wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment and alignment of the formwork and to allow it to be removed gradually without jarring the concrete.

3.20.04 Inspection of Forms

Casting of' Concrete shall start only after the formwork has been inspected and approved by the Engineer. The concreting shall start as early as possible within 3 (three) days after the approval of the formwork and during this period the formwork shall be kept under constant vigilance against any interference. In case of delay beyond three days, a fresh approval from the Engineer shall be obtained.

3.20.05 Removal of Forms

Formwork shall be kept in position after casting of concrete for a minimum period as mentioned in IS: 456, however the period of retaining form in position can be extended as per drawing, instruction of Engineer or as required for satisfactory completion of work without any extra cost. Before removing any formwork, the Contractor must notify the Engineer well in advance to enable him to inspect the concrete if the Engineer so desires.

The Contractor shall record on the drawing or in any other approved manner, the date on which concrete is placed in each part of the work and the date on which the formwork is removed there from and have this record checked and countersigned by the Engineer regularly. The Contractor shall be responsible for the safe removal of the formwork and any work showing signs of damage through premature removal of formwork or loading shall be rejected and entirely reconstructed by him without any extra cost to the Owner, The Engineer may, however, instruct to postpone the removal of formwork if he considers it necessary.

If any other type of cement other than ordinary Portland cement and Rapid hardening cement is used, the time of removal of forms shall be revised such that the strength of this cement at the time of removal of forms match with strength of Portland cement at the time of removal of form.

3.20.06 Tolerance

The formwork shall be so made as to produce a finished concrete, true to shape, lines, levels, plumb and dimensions as shown on the drawings subject to the following tolerances unless otherwise specified in this specification or drawings or directed by the Engineer:-

For - a) Sectional dimension - ± 5 mm
b) Plumb - 1 in 1000 of height
c) Levels - ± 3 mm before any deflection has taken place

The tolerance given above are specified for local aberrations in .the finished concrete surface & should not be taken as tolerances for the entire structure taken as a whole or for the setting and alignment of formwork, which should be as accurate as possible to the entire satisfaction of the Engineer. Any error, within the above tolerance limits or any other as may be specially set up by the Engineer, if noticed in any lift of the structure after stripping of forms, shall be corrected in the subsequent work to bring back the surface of the structure to its true alignment.

3.20.07 Re-use of Forms

Before re-use, all forms shall be thoroughly scraped, cleaned, joints and planes examined and when necessary repaired, and inside surface treated as specified hereinbefore. Formwork shall not be used/re-used if declared unfit or unserviceable by the Engineer.

3.20.08 Classification

Generally, the "ordinary" class formwork shall be used unless otherwise specified.

a) **Ordinary:** These shall be used in places where ordinary surface finish is required and shall be composed of steel and/or approved good quality partially seasoned timber.

b) **Plywood:** These shall be used in exposed surfaces, where specially good finish is required and shall be made of approved brand of heavy quality plywood to produce a perfectly uniform and smooth surface conforming to the shape described in the drawing with required grain texture on the concrete. Re-use may only be permitted after special inspection and approval by the Engineer. He may also permit utilization of used plywood for the "ordinary" class, if it is still in good condition.

c) **Ornamental:** These shall be used where ornamental and curved surface are required and shall be made of selected best quality well seasoned timbers or of plywood, which can be shaped correctly.

3.21.00 Opening, Chases, Grooves, Rebates, Blockouts etc.

The Contractor shall leave all openings, grooves, chases, etc. in concrete work as shown on the drawings or as specified by the Engineer.

3.22.00 Anchor Bolts, Anchors, Sleeves, Inserts, Hangers/Conduits/Pipe and other misc. Embedded Fixtures

The Contractor shall build into concrete work all the items noted below and shall embed them partly or fully as shown on drawings and secure the same as may be required. The materials shall be as specified and be of best quality available according to relevant Indian Standards of approved manufacture and to the satisfaction of the Engineer. Exposed surfaces of embedded materials are to paint with one coat of approved anti- corrosive paint and/or bituminous paint without any extra cost to the Owner. If welding is to be done subsequently on the exposed surface of embedded material, the paint shall be cleaned off the member to a minimum length of 50 mm beyond each side of the weld line.

Necessary templates, jigs, fixtures, supports etc. shall be used as may be

required or directed by the Engineer.

Items to be embedded

a) Inserts, hangers, anchors, frame around openings, manhole covers, frames, floor clips, sleeves conduits and pipes.

b) Anchor bolts and plates for machinery, equipment and for structural steel work.

c) Steel structurals to be left embedded for future extension, special connection etc.

d) Dowel bars, etc. for concrete work falling under the scope of other contractors.

e) Lugs or plugs for door and window frames occurring in concrete work.

f) Flashing and jointing in concrete work.

g) Any misc. embedments and fixture as may be required.

Correct location and alignment, as per drawings/instruction of all these embedded items shall be entirely the responsibility of the Contractor.

3.23.00 Expansion and Isolation Joints

3.23.01 General

Expansion and isolation joints in concrete structures shall be provided at specific places as per details indicated on the drawings. The materials and types of joints shall be as specified hereinafter. In case of liquid retaining structures, additional precautions shall be taken to prevent leakage of liquids as may be specified on the drawings or as directed by the Engineer. All materials are to be procured from reliable manufacturers and must have the approval of the Engineer. Where it is the responsibility of the Contractor to supply the material, the Engineer may demand test certificates for the materials and/or instruct the Contractor to get them tested in an approved laboratory free of cost to the Owner. Joints shall be formed true to line, level, shape, dimension, and quality as per drawings and specifications. Prior approval of the method of forming the joints should be obtained from the Engineer before starting the work.

3.23.02 Bitumen Board/ Expanded Polystyrene Board

a) Bitumen Board

Bitumen impregnated fibreboard of approved manufacturer as per IS: 1838 may be used as fillers for expansion joints. It must be durable and waterproof. It shall be compressible and possess a high degree of rebound. The dimensions of the board should be equal to that of the joint being formed. It should, preferably be manufactured in one piece, matching the dimension of the joint and not prepared by cutting to size smaller pieces from larger boards at site. At the exposed end, the joint shall be sealed with approved sealing compound to a depth of at least 25 mm after application of an approved primer. The sealing compound and the primer shall be applied as specified by the manufacturer.

b) Expanded Polystyrene Boards

If required, commercial quality of expanded polystyrene products commonly used for thermal insulations may also be used as filler material in expansion joints. The thickness may vary from 12 mm to 50 mm. The material will have to be procured from reliable manufacturers as approved by the Engineer. The method of installations will be similar to that recommended by the manufacturers for fixing on cold storage walls. A coat of Bitumen paint may have to be applied on the board against which concrete will be placed.

3.23.03 Joint sealing strips

Joint sealing strips may be provided at the construction, expansion, and isolation joints as a continuous diaphragm to contain the filler material and/or to exclude passage of water or any other material into or out of the structure. The sealing strips will be either metallic like G.I., Aluminums, or Copper, or non-metallic like rubber or P.V.C.

Sealing strips will not have any longitudinal joint and will be procured and installed in largest practicable lengths having a minimum number of transverse joints. The material is to be procured from reputed manufacturers having proven records of satisfactory supply of joint strips of similar make and shape for other jobs. The jointing procedure shall be as per the manufacturer's recommendations, revised if necessary, by the Engineer. The Contractor is to supply all labour and material for installation -including the material and tools required for jointing, testing, protection, etc. If desired by the Engineer, joints in rubber seals may have to be vulcanized.

a) Metal Sealing Strips

Metal sealing strips shall be either G.I., Aluminium or Copper and formed straight, U shaped, Z shaped or any other shape and of thickness as indicated in the drawing. The transverse joints will be gas welded using brass rods and approved flux and will be tested by an approved method to

establish that it is leak proof. If required, longer lap lengths and different method of brazing which will render it leak proof, will be adopted by the Contractor. The edges shall be neatly crimped and bent to ensure proper bond with the concrete.

i) G.I. Strips

G.I. strips shall be minimum 1.5 mm thick and 150 mm in width unless specified otherwise. The standard of Galvanizing shall be as per relevant Indian Standards for heavy-duty work. At the joints, the overlapping should be for a minimum length of 50 mm.

ii) Aluminium Strips

Aluminium strips shall be minimum 18 SWG thick and 300 mm wide unless specified otherwise and shall conform to IS: 737 of 19000 grades or 31000 grade (Designation as per IS: 6051). A minimum lap of 50 mm length is required at the joints.

iii) Copper Strips

The Copper strips shall be minimum 18 SWC in thickness and 300 mm width unless specified otherwise and shall conform to the relevant Indian Standards. It should be cleaned thoroughly before use to expose fresh surface, without any reduction in gauge. A minimum lap of 50 mm in length is required at the joints.

b) Non-metallic Sealing Strips

These will be normally in Rubber or P.V.C. Rubber or P.V.C. joint seals can be of shape having any combination of the following features:

i) Plain

ii) Central bulb

iii) Dumb-bell or flattened ends

iv) Ribbed and Corrugated Wings

v) V shaped

As these types of seals can be easily handled in very large lengths unlike metal strips, transverse joints will be allowed only under unavoidable circumstances and with the specific approval of the Engineer. The method of forming these joints, laps etc. shall be as specified by the Manufacturer and/or as approved by the Engineer taking particular care to match the

central bulbs & the edges accurately.

c) Rubber Sealing Strips

The minimum thickness of Rubber sealing strips shall be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings or as directed by the Engineer. The material will be natural rubber and be resistant to corrosion, abrasion, and tear and also to attacks from the acids, alkalis and chemicals normally encountered in service. The physical properties will be generally as follows. The actual requirements may be slightly different as decided by the Engineer:

Specific Gravity	:	1.1 to 1.15
Shore Hardness	:	65A to 75A
Tensile Strength	:	25 - 30 N/Sq.mm
Maximum Safe Continuous Temperature	:	75°C
Ultimate Elongation	:	Not less than 350%

b) P.V.C., Sealing Strips

The minimum thickness of P.V.C. sealing strips will be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings or as directed by the Engineer. The material should be of good quality Polyvinyl Chloride highly resistant to tearing, abrasion, and corrosion as well as to chemicals likely to come in contact with during use. The physical properties will generally be as follows. The actual requirements, which will be directed by the Engineer, may vary slightly

Specific Gravity	:	1.3 to 1.35
Shore Hardness	:	60A to SOA
Tensile Strength	:	10 - 15 N/Sq.mm
Maximum Safe Continuous Temperature	:	70 Deg.C
Ultimate Elongation	:	Not less than 275%

3.23.04 Bitumen Compound

When shown in drawing or directed, the gap in expansion joints shall be

thoroughly cleaned and bitumen compound laid as per manufacturer's specifications. The compound to be used shall be of approved manufacture and shall conform to the requirements of IS: 1834.

3.23.05 Isolation Joints

Strong and tough alkathene sheet or equivalent, about 1 mm in thickness and as approved by the Engineer shall be used in isolation joints. It shall be fixed by an approved adhesive compound on the cleaned surface of the already set concrete to cover it fully. Fresh concrete shall be laid against the sheet, care being taken not to damage the sheet in any way.

3.23.06 Pad

Hard foundation quality rubber pads of required thickness and shapes shall be put below machine or other foundations as shown on the drawings. The rubber shall have a unit weight of 1500 Kg/Cu.m, a shore hardness - 65A to 70A and be of best quality of approved manufacture, durable, capable of absorbing vibration and must be chemically inert in contact with moist or dry earth or any other deleterious material expected under normal conditions.

3.24.00 Grouting under Machinery or Structural Steel Bases

If required, grouting under base plates of machines or structural steel etc. shall be carried out by the Contractor. In general, the mix shall be 1 (one) part cement and 1 (one) part sand and just enough water to make it flow as required. The areas to be grouted shall be cleaned thoroughly with compressed air jet and/or with water in locations where accumulated surplus water can be removed. Where directed by the Engineer, 6 mm down stone chips may have to be used in the mix. Surface to be grouted shall be kept moist for at least 24 hours in advance. The grout shall be placed under expert supervision, so that there is no locked up air. Edges shall be finished properly. If specified on drawings, admixtures like Aluminium powder, "Ironite" etc. may have to be added with the grout in required proportions. Premixed non-shrink grout of approved manufacture having proper strength shall be used with Engineer's approval for important machineries.

3.25.00 Precast Concrete

The Specification for precast concrete will be similar as for the cast-in-place concrete described herein and as supplemented in this section. All precast work shall be carried out in a yard made for the purpose. This yard shall be dry, properly levelled and having a hard and even surface. If the ground is to be used as a soffit former of the units, it shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportion) with smooth neat cement finish or a layer of M.S. sheeting. Where directed by the Engineer, casting will have to be done on suitable vibrating table. The yard,

lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 7 (seven) days of curing and can be removed for erection after 28 (twenty-eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I. sheet metal. The yard shall preferably be fenced.

Lifting hooks, where necessary or as directed by the Engineer, shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drawings, and shall be burnt off and finished after erection.

Precast concrete units, when ready, shall be transported to site by suitable means approved by the Engineer. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling, and plumbing shall be done as per instructions of the Engineer. The Contractor shall render all help with instruments, materials, and men to the Engineer for checking the proper erection of the precast units.

After erection and alignment, the joints shall be filled with grout or concrete as per drawings. If centrings have to be used for supporting the precast units, they shall not be removed until the joints have attained sufficient strength and in no case before 14 (fourteen) days. The joint between precast roof planks shall be pointed with 1:2 cement: sand mortar where called for in the drawings.

3.26.00 Waterproofing of Concrete Structure

3.26.01 General

Where required, waterproofing of concrete structures shall be ensured internally by suitable design of the concrete mix, addition of suitable admixtures in the concrete or mortar at the time of mixing and/or installing water bars at the joints. In addition to the above measures, the structures shall be made watertight by adopting "structural waterproofing" as per specification. The design, material, and workmanship shall conform to the relevant I.S. Codes where applicable. The Engineer's approval of the materials shall be obtained by the Contractor before procurement. If desired by the Engineer, test certificates for the materials and samples shall be submitted by the Contractor free of charge. The materials shall be of best quality available indigenously, fresh clean and suitable for the duties called upon.

3.26.02 Water Bar/Seal/Special Treatment of Construction Joint

Water bearing structures and underground structures may have water bar/seals installed at the joints. They may be metallic, rubber, or P.V.C. The materials and installation will be as described under Clause 3.23.3. Construction joint shall be provided as per clause 3.13.1 with or without water bar/seal as shown

on the drawing. In case of water bars being used at the construction joint, fixing of the same has to be done carefully, so that the water bar is not disturbed during concreting. The construction joint shall also be treated by any one of the following methods.

Method 1: A surface retarder in the form of a thixotropic gel shall be applied on the joint surface of the previous pour in case of joint on the wall and in case of floor the same shall be applied on the formwork against which previous pour of concreting shall be done. The retarder may be liquid or paste form depending on the type of formwork. The formwork shall be removed within 24 hours after concreting. Within 2 hours of striking of the formwork the retarder shall be washed off with strong water jet to make surface rough and clean. Then a rich cement mortar using cement, sand and aggregates (maximum size 8 mm) along with synthetic rubber emulsion type water resistant bonding agent shall be applied for a depth of 50 mm just before pouring the next stage of concreting. In case of walls, the above bonding agent will be mixed with water, which will be used for making the cement mortar. The proportion of mixing of this bonding agent with water shall be as per manufacturer's specification. In case of floor joint, however, after washing of retarder a solvent free two-component epoxy resin-bonding agent will be used at the joint before the next pour of concrete. The above bonding agent shall have the following properties after 28 days

Compressive strength	-	55 to 60 N/Sq.mm
Flexural strength	-	5 to 30 N/sq.mm
Tensile strength	-	15 N/Sq.mm (approx.)
Bonding strength to concrete	-	3 N/Sq.mm (approx.)
Bonding strength to steel	-	20 N/Sq.m (approx.)

The whole operation shall be done as per manufacturers specification. The contractor shall provide manufacturer's supervision at no extra cost to the owner.

Method 2: One row of threaded nozzles at regular intervals not exceeding l.5 m centre to centre shall be placed in concrete along the construction joint during casting. Injection of cement water together with a suitable waterproof expanding grouting admixture of approved quality shall be done through the nozzles after the concrete has set to seal the voids in concrete near the construction joint in walls and slabs. The injection shall be done under pressure of approximately 2 to 4 kg/sq.cm. The nozzles shall be sealed off with suitable admixture after the injection is over. The whole operation shall be carried out as per manufacturer's specification and supervision. The cost of such manufacturer's supervision shall be borne by the contractor.

3.26.03 Waterproofing Admixtures

The waterproofing admixture for concrete and cement mortar/plaster shall conform to IS: 2645. The admixture shall not cause decrease of strength of concrete/plaster at any stage and it shall be free from chlorides and sulphates. The admixture shall not affect the setting time by more than 5%. The maximum permissible dosage of admixture will be 3% (three percent) by weight of cement, but a lower dosage will always be preferred. The product shall be stored in strong moisture proof packings. However, in case of important structures where M25 or higher grade concrete is specified, the use of melamine based, high range water reducing concrete admixture shall be used to provide a waterproof concrete, For achieving high strength concrete having cement content around 400 kg/cu.m. a melamine based super plasiticizer will be preferable.

a) In concrete: The admixtures shall be procured from reliable and reputed manufacturers and approved by the Engineer. The method of application and other details shall conform to the manufacturer's specification and/or as instructed by the Engineer. The Contractor shall have the services of the manufacturer's supervisor at no extra cost to supervise the work, if desired by the Engineer.

b) In Plaster: The concrete surface, to be plastered, shall be hacked to Engineer’s satisfaction, cleaned thoroughly and kept wetted for 24 hours. The plaster shall be in cement sand mortar mixed in proportion varying from 1:1 to 1:4 by volume along with the approved waterproofing admixture and laid in appropriate thickness and in layers not exceeding 15 mm/layer or as per manufacturer's specification. The additive shall be of quality and type approved by the Engineer. If desired by the Engineer, the Contractor shall have the work supervised by the manufacturer's supervisor at no extra cost. On completion, the Plastered surface shall be cured continuously for a minimum period of 14 days like concrete.

3.26.04 Structural waterproofing

a) Nozzles spaced as required after the concrete is completed shall be drilled into surfaces to be rendered watertight. Non-shrink cement grout with waterproofing compound as per manufacturers specifications shall be injected under pressure to seal all voids. Special care shall be taken at joints by providing additional nozzles. The pressure grouting shall be done on the internal surface.

b) External Treatment

Two layers of (1:4) plaster of 12 mm thick each with waterproofing compound as per manufacturer's specification shall be provided on outer

surface of concrete underground structures.

3.26.05 Protective coating on Inside Surface.

Two coats of cement based two components polymer modified flexible protective and waterproofing slurry having 1 mm thick for each coat shall be applied on the walls/floor after proper surface preparation as mentioned above. The slurry shall be applied by brush.

3.26.06 Bitumen Felt: Application for Tanking

This specification shall cover laying the waterproof course on the outside and inside of the walls and bases of structures.

The materials shall conform to IS: 1322, and the workmanship to IS: 1609. The bitumen felt should be hessian base and/or fibre base as specified in Drawing. If required by the Engineer, tests as specified in relevant IS Codes shall be arranged by the Contractor without charging any extra to the Owner.

The Contractor shall execute this work in direct collaboration with one of the well-known specialized firm approved by the Engineer.

Cleaning the surface, keeping it dry, providing, necessary corner fillets and cement rendering and cutting chases, etc. shall be done as per drawings and/or instructions. If any protective brickwork on/against concrete sub-bases or walls are required, the same shall be provided. A twenty (20) years guarantee for satisfactory performances shall be given by the Contractor as well as his specialist sub-contractor jointly and severally, for this work. Free rectification of any defects noted in the work within this guarantee period will be carried out by the Contractor even if it is beyond the specified maintenance period of the contract as a whole.

3.26.07 Polyethylene Films: Application in Walls or base of structures

Waterproof treatment shall be applied as outlined and as per sequence given hereunder

i) the concrete surface shall be made smooth with 12 mm cement plaster 1:6.

ii) apply hot bitumen 80/100 grade (IS: 73-1961) at the rate of 1.0 Kg/Sq.m minimum

iii) lay black polyethylene film 250-micron (IS: 2508-1977) with cut back bitumen adhesive in overlaps over hot bitumen surface, gently pressed, taking care not to puncture the film.

Alternatively, the overlaps shall be heat sealed by an electric iron having

three parallel sealing bars. A long piece of plywood is to be placed below the polyethylene film to be heat-sealed. On the plywood a rubber gasket is to be laid to provide a cushion for better welding of the film. On the rubber padding, a cellophane tape is to be spread and on this the LDPE film, with 100 mm overlap, is to be stretched. On the overlapped film another cellophane tape is to be placed to prevent the heat sealer from sticking to the LDPE film. After this, the electric iron is to be pressed on the overlap joint for sufficient time so as to allow perfect welding. The operation is to be repeated for subsequent lengths of joints. After heat-sealing, the cellophane tape is to be removed and the joints are to be tested for leaks.

iv) Lay 100 gm brown craft paper laminated with a layer of straight run bitumen,

v) Lay hot bitumen 80/100 grade (IS: 73-1961) at 1.0 Kg/Sq.m minimum.

vi) Lay 250-micron polyethylene film as second layer similar to (iii)above.

viii) Lay second layer of 100 gm. brown craft paper laminated similar to (iv) above.

ix) Apply hot bitumen (straight run grade) to IS: 73-1961 at 1.0 Kg/Sq.m dusted with fine sand.

x) Protecting with a layer of 75 mm plain cement concrete M-10, or a layer of brick laid in cement mortar 1:6 in case of wall apply a 12 mm thick plaster as shown on the drawing or a protective brick wall in 1:6 cement mortar as shown on the drawing.

3.27.00 Protective Coating on Concrete Surface

3.27.01 On Foundation

The outside faces of foundation of important structures will be protected from adverse effect of soil/underground water, if shown on drawing by using rubber/bitumen emulsion protective coating of approved manufacturer.

4.00.00 SAMPLING AND TESTING

4.01.00 General

The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost unless otherwise specified in this specification. The Contractor shall get the specimens tested in a laboratory approved by the Engineer and submit to the Engineer the teat results in triplicate within 3 (three) days after completion of the test.

4.02.00 Cement

Representative samples will be taken from each consignment of cement received from the manufacturer/supplier for carrying out the tests for fineness (by hand sieving), setting time and compressive strengths as per guidelines of IS: 269. Soundness Tests may also be required to be carried out if required by the Engineer. The Contractor shall carry out the tests without any expense to BHEL. No cement from a particular consignment/batch will be used on the works unless satisfactory 3 (three) days and 7 (seven) days test results for compressive strength are known. The Engineer and Contractor will jointly associate themselves with the tests irrespective of whether they are carried out by the BHEL or the Contractor. These tests are of great importance, as their results will have a bearing on the acceptance of concrete or otherwise as per the terms and conditions of the Contract.

4.03.00 Aggregates

The contractor shall carry out any or all the tests on aggregates as may be required by the Engineer in accordance with IS: 2386 PARTS-I to VIII. The acceptance criteria of the samples tested shall be in accordance with the requirements of the relevant Indian Standards.

4.04.00 Water

Sampling and Testing of water being used for concrete works as per IS: 3550 will be carried out by the Contractor at regular intervals and whenever directed by the Engineer. The acceptance criteria will be as per IS: 456.

4.05.00 Admixture

4.05.01 Air Entraining Agents

Initially, before starting to use A.E.A., relationship between the percentage of air entrained and the cylinder cube crushing strength vis-a-vis quantity of A.E.A. used for all types of concrete will be established by the Contractor by carrying out sufficiently large number of tests. After that, at regular intervals and whenever directed by the Engineer, the Contractor will check up the actual percentages of air entrained and corresponding crushing strengths to correlate with the earlier test results.

4.05.02 Other Admixtures

Tests for establishing the various properties of any other admixtures, which may be required to be added, shall be carried out by the Contractor.

4.06.00 Concrete

The sampling of concrete, making the test specimens, curing and testing procedure etc. shall be in accordance with IS: 516 and IS: 1199, the size of specimen being 15 cm cubes. Normally, only compression tests shall be performed but under special circumstances the Engineer may require other tests to be performed in accordance with IS: 516. Sampling procedure, frequency of sampling and test specimen shall conform to IS: 456. To control the consistency of concrete from every mixing plant, slump tests shall be carried out by the Contractor every two hours or as directed by the Engineer. Slumps corresponding to the test specimens shall be recorded for reference. The acceptance criteria of concrete shall be in accordance with IS: 456. Concrete work found unsuitable for acceptance shall have to be dismantled and replacement is to be done as per specification by the Contractor at his own cost. In the course of dismantling, if any damage is done to the embedded items or adjacent structures, the same shall be made good, free of charge by the Contractor, to the satisfaction of the Engineer.

5.00.00 ACCEPTANCE CRITERIA

5.01.00 Standard Deviation

Standard deviation shall be based on test results and determination of Standard deviation shall conform to IS: 456.

5.02.00 Acceptance Criteria

The strength requirements and acceptance criteria shall conform to IS: 456.

5.03.00 Inspection and Core Tests

Inspection of concrete work immediately after stripping the formwork and core test of structures shall conform to IS: 456.

5.04.00 Load Test

Load tests of structural members as per IS:456 may be required by the Engineer, when the strength of test specimen results falls below the required strength.
If the member shows evident failure, the Contractor shall make the structure adequately strong free of cost to BHEL.

The entire cost of load testing shall be borne by the Contractor. If a portion of the structure is found to be unacceptable, it shall be dismantled and replaced by a new structure as per specification. The entire cost of dismantling and replacement and restoration of the site being borne by the Contractor.

If, in the course of dismantling, any damage is done to the embedded items

and or other adjacent structures, the same will be made good, free of charge by the Contractor to the satisfaction of the Engineer.

6.00.00 RATES AND MEASUREMENTS

6.01.00 Cast-in-situ Concrete

6.01.01 Rates

a) The unit rates shall include the cost of labour, materials, equipment, handling, transporting, botching, mixing, placing in position, vibrating, compacting, finishing, curing, testing, etc. at all elevations. This shall include the cost of curing by regular wetting or by using curing compound.

b) The unit rates shall include for all working conditions including at locations under water, liquid, mud, in or under foul positions and extreme weather conditions.

c) The unit rates for exposed concrete works (including machine foundations) shall include all incidentals, rendering, smoothening with carborandum stone, finishing with a paste of cement sand mortar, curing, etc.

d) The unit rates shall include all arrangement for maintaining stability of structure during execution.

e) Nothing extra shall be payable for the handling/mixing of extra cement on account of any reason or pouring of second stage concrete.

f) Nothing shall be payable to the Contractor on account of facilities and arrangement provided by him for conducting ultrasonic pulse velocity (UPV) tests or other relevant tests to ascertain grade and quality, etc. of the concrete in case the concrete quality is in doubt and contractor has to establish the quality by further tests. In case of any defects, the Contractor shall rectify the same by cement/epoxy grout at his own cost.

However, mandatory UPV test as specified in the drawings shall be carried out including arrangement of all its facilities, staging, etc. and shall be payable to the contractor as per BOQ item.

g) The unit rates for controlling of the temperature of concrete shall include storing and mixing of ice, water, cooling of aggregate etc.

h) The quoted rate shall include the cost of MIX design, making of all trial mixes using admixtures and mixing in concrete etc. complete.

6.01.02 Measurements

a) Actual volume of concrete work as executed or as per drawings issued, whichever is less shall be measured in cubic metres to the nearest two decimals.

b) No deductions shall be made for the following:

i) Ends of dissimilar materials embedded inside for example, beams, posts, girders, rafters, purlins, trusses, corbels and steps upto 500 sqcm in cross section;

ii) Opening upto 0.1 sq.m.

iii) Volume occupied by reinforcement, sleeves, anchor bolts, and similar items.

iv) Volume occupied by pipes, conduits, sheathing, etc. not exceeding 100 sq.cm. each in cross sectional area.

c) The concrete works of different grades; below and above ground floor finished level shall be measured separately, unless otherwise specified in the schedule of items. Accordingly rates shall be applied for concrete in foundation for concrete below ground floor finished level and concrete in superstructure for concrete above ground floor finished level.

d) For temperature control measures, measurement shall be done in terms of quantity of concrete in cum. in concreting of which the ice have been used or cooling of aggregates has been done to keep the temperature of freshly laid concrete to less than 23^0C.

6.02.00 Reinforcement

6.02.01 Rates

a) The unit rates shall include for cover block, providing binding wire, welding, separator pieces between two or more layers of reinforcement required for keeping the steel in position, etc. at all elevations.

b) No extra will be paid for transportation from stores, cleaning, straightening of steel, cutting, bending, binding with annealed wire, welding, tack welding, placing the reinforcement modification of already embedded reinforcement, if required, due to faulty fabrication or placement and other cost of tools and plants, materials, labours, return of unused steel to the store, etc.

c) However, lap welding of reinforcement steel if permitted shall be paid under separate item as provided in the BOQ and no deduction for labour

and binding wire saved for not providing lap length shall be made. Similarly, splicing of reinforcement bars using mechanical couplers if permitted shall be paid under separate item as provided in the BOQ and no deduction for labour and binding wire saved for not providing lap length shall be made.

d) No extra shall be paid for preparing and getting approved bar bending schedules (including all revisions).

e) Generally members are straight and have straight edges. However, for bending, binding, placing of reinforcement in any curved member in length or cross section or both, no extra payment shall be made.

6.02.02 Measurements

a) Bar or any other type of reinforcement used like hard drawn steel wire fabric etc. for reinforced concrete shall be measured by weight in tonnes. The weight shall be arrived at by multiplying the actual or theoretical length measured alongwith standard hooks, cranks, bends, authorized laps, etc. whichever is less by the sectional weights. Claims for payment for this item shall be submitted with supporting documents giving the schedule of bars with sketches. The sectional weight to be adopted shall be IS Section weight. Nothing extra will be payable to the Contractor on account of, difference in weight, if any, due to different methods adopted for issue and measurement.

b) Standard hooks, cranks, bends, authorised laps, supports, hangers and chairs which are covered in approved bar bending schedule shall be measured in tonnes.

6.03.00 Formwork and Staging

6.03.01 Rates

a) The unit rates shall be inclusive of all staging, scaffolding, making the formwork watertight, etc. for all elevations and in all types of works.

b) No separate payment shall be made for providing fillets, for rounding or chamfering at junctions, comers, etc.

c) The unit rates shall include the cost of labour, materials etc. and the extra time, which shall be required for the removal of shuttering/ support for satisfactory completion of work.

d) No extra payment shall be made on account of difficulty, wastage etc. for placement/removal of formwork between the network of closely placed steel beams or for the lacing/bracing portions and ribbed slab constructions.

e) Payment for curved shuttering shall be made for curved members/wall whose centerline radius in plan is less than 6m.

f) If the contact surface area in pockets is less than or equal to 0.1 sq.m. in each case, payment shall be done under item for providing formwork in pockets.

6.03.02 Measurements

a) Formwork for different classes (types) shall be measured separately as the actual surface in contact with the concrete and paid on area basis unless included in the rate for concrete. The unit of measurement shall be in sq.m.

b) Openings upto 0.1 sq.m or boxing left for inserts etc. for facility of Contractor's work, shall be neglected as if nonexistent for the purpose of formwork measurement of surface in which the openings occur.

For suspended floor, no deduction shall be made for flange area of secondary steel beams.

d) No measurement shall be taken for the formwork in pockets, openings, chases, blockouts, etc. in concrete, the contact surface area is less than or equal to 0.1 sq.m. in each case.

e) For pockets, if the contact surface area is less than or equal to 0.1 sq.m. in each case, measurement shall be done under item for providing formwork in pockets.

e) Formwork, if required, for joints shown on drawing or instructed by the Engineer, shall be paid for the 'leading side' only.

6.04.00 Embedded Parts

6.04.01 Rates

a) The unit rate for erection of embedded steel parts, supplied by Engineer shall include transportation from Owner's store to the place of work, erection & installation including setting material in concrete, etc. complete.

b) The unit rate for MS pipe embedments and PVC pipe embedments shall include cutting, welding, fabrication, erection, embedding, and transportation to site. Unit rate shall also include the cost of the pipes.

c) Rate for expansion fasteners shall include cost of fasteners, installation, and fixing including cost of washers and nuts and site testing if required.

6.04.02 Measurements

a) The measurement of the embedded steel parts fabricated and installed by the Contractor shall be based on the calculated weight of steel sections in tonne corrected to second place of decimal.

b) Embedded steel parts supplied by Owner and installed by Contractor Measurement shall be done for the net weight of the embedments installed in tonnes correct to second place of decimal.

c) For PVC pipes/conduits, measurements shall be in quintals correct to second place of decimal for the net weight.

d) For mild steel pipes, measurement shall be in quintals, correct to second place of decimal, for the net weight of the steel pipe supplied, fabricated, and installed.

e) The lugs shall be measured in Kg. correct to second place decimal for the net weight.

f) The expansion fasteners shall be measured in number according to tension capacity.

g) The rails shall not be treated as embedded steel part and the track shall be measured in running metres along the centre line and paid for under separate item of work as specified in schedule of items. Other related civil items associated with the laying of track shall be measured separately and paid under respective items of works.

6.05.00 Groutings

6.05.01 Rates

Rate shall include the cost of surface preparation, admixtures, and curing.

6.05.02 Measurements:

a) Measurement shall be in cubic decimeters.

b) Measurement for grouting shall be by volume of the block out, pockets or bolt hole upto the top surface of foundation concrete and shall be calculated from the dimensions shown on the drawings.

c) Measurement for underpinning shall be by volume between the top surface of the foundation concrete and the underside of the base plate, the plan dimensions being as indicated on the drawings.

d) No deduction shall be made for shims, bolts, shear keys and such other embedments.

f) Pressure injection grouting with cement based grout if required as per drawing shall be applied at appropriate spacing to cover the desired surface area and measurement shall be made for the surface area grouted in sqm as per BOQ item. However in water retaining structures, the structural grouting if required to ensure water tightens shall not be payable separately as deemed to be covered in water retaining concrete item of BOQ.

6.06.00 Joints

6.06.01 Rates

The unit rate shall include all the activities described in the schedule of items.

6.06.02 Measurements

a) Bitumen Board/Expanded polystyrene.

The measurement for bitumen board shall be based on actual finished surface area in square meters nearest to second decimal, for the specified thickness.

b) Water Stops

The measurement for water stops shall be in running metres of actual length of the joint covered, for specified thickness, width, and shapes. No separate measurement shall be made for laps/splices for cross-joints and mitered joints.

c) Metal Cover Strips

The measurement for Metal Cover Strips shall be based on actual finished surface area in square metres for the specified thickness.

d) Vibration Damping Resilient Pads

The measurement for this item shall be in square metres for the specified thickness, measured correct to the second place of decimal, of the actual finished surface area.

6.07.00 Dismantling/Demolishing Work – RCC and PCC and Chipping of Concrete

6.07.01 Rates

The unit rates shall include the cost of all necessary propping, shoring, underpinning scaffolding, safety measures, temporary enclosures, disposal/ stacking of serviceable/unserviceable materials, etc. for all types of work and for all grades of concrete.

In the case of dismantling/demolishing work, the cutting of reinforcement shall also be included in the rate.

In the case of chipping work, the cutting of reinforcement shall be paid separately.

If the serviceable material including reinforcement steel from dismantled structure is allowed to be used/taken out by bidder, suitable rebate shall be given by bidder.

6.07.02 Measurements

a) Dismantling of PCC and RCC work shall be measured in cu.m separately. Measurement of all work, except hidden work shall be taken before execution of work and no allowance for increase in bulk shall be allowed. Specifications for deductions of voids, openings etc, shall be done on the same basis as that applied for construction work.

b) Chipping of concrete, making holes/pockets etc. shall be measured in cubic decimeters (i.e. 0.001 cu.m.).

c) Cutting of reinforcement in chipping work for making of pockets and openings shall be measured in sq. cm. of cross-sectional area.

6.08.00 Precast Concrete

This clause shall be read in conjunction with relevant provisions specified elsewhere for cast in-situ Concrete.

6.08.01 Rates

a) The unit rate shall include cost of preparation of casting yard, formwork, concrete and its casting, finishing as specified, setting filling of gaps between adjacent pre-cast concrete units with concrete, or cement mortar, curing, handling, erection, grouting, welding, preparation of supporting surface, etc.

6.08.02 Measurements

The measurement of pre-cast concrete members shall be on the basis of

volume of concrete in cubic metres nearest to second place of decimal. No deduction shall be made for volume occupied by reinforcement/inserts/sleeves and for openings up to 0.1 sq.m. The setting of element with cement mortar shall not be measured separately The filling of concrete cement mortar between the gaps of adjacent precast units shall be considered while computing the volume of pre-cast concrete work and shall be paid for under this item itself.

7.00.00 LIST OF IS CODES AND STANDARDS FOR REFERENCE

All work under this specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not specifically covered by Indian standard Specifications, any other standard practice, as may be specified by the Engineer, shall be followed:-

IS: 73 - Indian Standard Specification for Paving Bitumen

IS: 216 - Indian Standard Specification for Coal Tar Pitch

IS: 383 - Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete

IS: 432 - Indian Standard Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for concrete Reinforcement

IS: 455 - Indian Standard Specification for Slag Cement

IS: 456 - Indian Standard Code of Practice for Plain and Reinforced Concrete

IS: 457 - Indian Standard Code of Practice for General Construction of Plain and Reinforced Concrete for Dams and other Massive Structures

IS: 516 - Indian Standard Specification for Methods of Test for Strength

of Concrete

IS: 702 - Indian Standard specification for industrial bitumen.

IS: 1199 - Indian Standard Specification for Methods of Sampling and Analysis of Concrete

IS: 1322 - Indian Standard Specification for Bitumen Felts for Waterproofing and Damp-proofing

IS: 1489 - Indian Standard Specification for Portland Pozzolona Cement

IS: 1566 - Indian Standard Specification for hard drawn steel wire fabric for concrete reinforcement.

IS: 1609 - Code of Practice for Laying Damp-proof Treatment using Bitumen Felts

IS: 1786 - Indian Standard Specification for High Strength Deformed Steel Bars and Wires for Concrete Reinforcement.

IS: 1791 - Indian Standard Specification for Batch Type Concrete Mixers.

IS: 1838 - Indian Standard Specification for preformed fillers for expansion joints in concrete pavements and structures (non-extruding and resilient type.

IS: 2185 - Indian Standard Specification for Hollow Cement Concrete Blocks

IS: 2210 - Indian Standard Specification for Design of Reinforced Concrete shell Structures and Folded Plates

IS: 2386 - Indian Standard Specification for Methods of Test for Aggregates for Concrete - Part-I to VIII

IS: 2502 - Indian Standard Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement

IS: 2505 - Indian Standard Specification for Concrete Vibrators, Immersion Type

IS: 2506 - Indian Standard Specification for Screed Board Concrete Vibrators

IS: 2514 - Indian Standard Specification for Concrete Vibrating Tables

IS: 2571 - Code of practice for laying in-situ cement concrete floors.

IS: 2645 - Integral cement water proofing compound

IS: 2722 - Indian Standard Specification for Portable Swing Weigh Batchers for Concrete (Single and Double Bucket type)

IS: 2750 - Indian Standard Specification for steel scaffoldings.

IS: 2751 - Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction

IS: 2770 - Indian Standard Specification for Method of Testing Bond in Reinforced Concrete

IS: 3025 - Indian Standard specification for Methods of Sampling and Test (Physical and Chemical) for Water used in Industry

IS: 3067 - Code of practice for general design details and preparatory work for damp proofing and water proofing of building.

IS: 3201 - Indian Standard Specification for Design and Construction of Precast Concrete Trusses

IS: 3370 - Indian Standard Specification for Code of Practice for Concrete Structures for Storage of Liquids

IS: 3414 - Code of practice for design and installation of joints in buildings.

IS: 3550 - Indian Standard Specification for Method of Test for Routine Control for Water used in Industry

IS: 3558 - Code of Practice for use of Immersion vibrators for Consolidating Concrete

IS: 3696 - Safety Code for Scaffolding and Ladders

IS: 3812 - Indian Standard Specification for Fly Ash for Use as Admixture for Concrete

IS: 4014 - Code of practice for steel tubular scaffolding.

IS: 4031 - Indian Standard Specification for Method of Tests for Hydraulic Cement

IS: 4082 - Indian Standard Specification for Recommendation on

Stacking and Storage of Construction Materials at site

IS: 4090 - Indian Standard Specification for Design of Reinforced Concrete Arches

IS: 4634 - Indian Standard Specification for Method of Testing Performance of Batch-type Concrete Mixes

IS: 4656 - Indian Standard Specification for Form Vibrators for Concrete

IS: 4925 - Indian Standard Specification for Concrete Batching and Mixing Plant

IS: 4926 - Indian Standard Specification for Ready Mixed Concrete

IS: 4990 - Indian Standard Specification for Plywood for Concrete Shuttering work

IS: 4991 - Indian Standard Specification for Blast Resistant Design of structure for Explosion above ground

IS: 4995 - Indian Standard Specification for Design of Reinforced Part-I & II Reinforced Concrete Bins for the Storage of Granular and Powdery Materials

IS: 4998 - Indian Standard Specification for Design of Reinforced Concrete Chimneys.

IS: 5256 - Code of practice for sealing joints in concrete lining on canals.

IS: 5512 - Indian Standard Specification for Flow Table for use in Tests of Cement and Pozzolanic materials

IS: 5513 - Indian Standard Specification for vacate Apparatus.

IS: 5515 - Indian Standard Specification for Compaction Factor Apparatus.

IS: 5525 - Recommendation for detailing of reinforcement in reinforced concrete works.

IS: 5624 - Indian Standard Specification for foundation bolts.

IS: 5751 - Indian Standard Specification for Precast Concrete Coping Blocks.

IS: 5816 - Indian Standard Specification for Method of Test for Splitting

Tensile strength of Concrete Cylinders.

IS: 5891 - Indian Standard Specification for Hand operated Concrete Mixers.

IS: 5892 - Indian Standard Specification for transit mixer and agitators.

IS: 6452 - Indian Standard Specification for High Alumina Cement for Structural Use

IS: 6909 - Indian Standard Specification for Super sulphated Cement

IS: 6923 - Indian Standard Specification for Method of Test for Performance of Screed Board Concrete Vibrators.

IS: 6925 - Indian Standard Specification for Method of Test for Determination of Water Soluble Chloride in Concrete Admixtures.

IS: 7242 - Indian Standard Specification for Concrete Spreaders.

IS: 7246 - Indian Standard Specification for Table Vibrators for Consolidating Concrete.

IS: 7251 - Indian Standard Specification for Concrete Finishers.

IS: 7293 - Safety code for working with construction machinery.

IS: 7320 - Indian Standard Specification for Concrete Slump Test Apparatus.

IS: 7861 - Indian Standard Specification for Recommended Practice Part-I&II for Extreme Weather Concreting.

IS: 7969 - Safety Code for Storage and Handling of Building Materials.

IS: 8041 - Indian Standard Specification for Rapid Hardening Portland cement.

IS: 8112 - Indian Standard Specification for high strength Ordinary Portland Cement.

IS: 8142 - Indian Standard Specification for Determining Setting time of concrete by Penetration Resistance.

IS: 8989 - Safety Code for Erection of Concrete Framed Structures.

IS: 9012 - Recommended method for shortcreting.

IS: 9013 - Indian Standard Specification for Method of Making, Curing, and determining compressive Strength of Accelerated-cured Concrete Test Specimens.

IS: 9077 - Code of Practice for Corrosion Protection of Steel Reinforcement in RB and RCC Construction.

IS: 9103 - Indian Standard Specification for Admixtures for Concrete.

IS: 10262 - Recommended Guidelines for Concrete Mix Design.

IS: 13311 - Non-destructive testing of concrete.

SP: 34 - Handbook of concrete, reinforcement and detailing.

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SECTION - D

SUB-SECTION – D3

CARPENTRY AND JOINERY

SPECIFICATION NO. PE-TS-999-600-C003

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
1.00.00	SCOPE	3
2.00.00	INSTALLATION	3
3.00.00	ACCEPTANCE CRITERIA	5
4.00.00	I.S. CODES	6
5.00.00	RATES AND MEASUREMENTS	6

CARPENTRY AND JOINERY

1.00.00 SCOPE

This section covers supply, fitting and fixing of timber frames to doors and windows with M S holdfasts, flush doors, windows, shutters, partitions, wall panelling, pelmets, shelves, furniture, etc. as shown in drawings, including a prime coat of approved paint, varnish, or fixing of decorative plastic laminate where called for. This shall also include the supply and fixing of all hardware and fixtures shown in drawing or specified.

2.00.00 INSTALLATION

2.00.01 Materials

a) Timber

Unless otherwise specified, all timber shall be best quality well-seasoned CP teakwood free from large or loose knots, cracks or any other defects. All timber shall be treated with approved wood preservative before use, unless specified otherwise. The rough timber shall be approved by the Engineer before incorporating in the works and starting the carpenter's work.

b) Plywood

Plywood shall be of commercial quality or with decorative surface veneer. Unless specifically permitted otherwise, the adhesive used in plywood shall be phenol formaldehyde synthetic resin of BWP grade conforming to IS: 848.

c) Decorative Laminated Plastic Sheets

The colour, pattern, finish and texture shall be approved by the Engineer. The bulk supply shall be procured in full sheet sizes which will ensure the least number or joints in one surface.

d) Flush Doors

Flush doors shall be solid core doors with commercial or decorative faces and hardwood edges conforming to IS: 2202 (Part-1). The core for solid core doors shall be of block board or wood particle board. Manufacturer's literature and test certificates shall be submitted for the approval of the Engineer. The Contractor shall give a guarantee that the adhesive used is BWP grade phenol formaldehyde synthetic resin conforming to IS: 848. The thickness shall be as specified.

e) Panel Doors

Panel door shall be of teakwood shutter frame, unless otherwise noted and panels with teakwood/commercial ply/teakwood particle board. Other considerations shall be as mentioned in item (d) above.

f) Windows, Ventilators

Windows and ventilators shall be made of teakwood shutter frame, unless specified otherwise and glazing of specified thickness shall be fixed with wooden beadings.

g) Fixtures

Fixtures for doors, windows, furniture etc. shall be as shown on drawing or specified.

2.02.00 Workmanship

2.02.01 General

The work shall be done by skilled carpenters as per details shown on drawing or instructed by the Engineer.

Framing timber and other work shall be close - fitting with proper wood joinery, accurately set to required lines or levels and rigidly secured in place. The surface of frames etc., which will come in contact with masonry after fixing, shall be given two coats of approved paint before fixing. Mastic caulking shall be done after fixing external door and window frames. Special care shall be taken to match the grain of timber or plywood, which will be subsequently polished. Screwing or nailing will not be permitted to the edge of plywood and particle board. The edge of all plywood, blackboard and particle board shall be finished with teakwood lipping unless otherwise shown on drawings.

Fixing to frames and partitions shall generally be with 40 mm x 6 mm x 300 mm long M S holdfasts bifurcated at end and grouted with 1:2:4 cement concrete. The gap between masonry and external door and window frame shall be caulked with polysulphide mastic. M.S. grills or guard bars shall be provided to windows where called for in the drawings.

2.02.02 Finish

All carpentry work after finishing shall be sand papered smooth. A prime coat paint shall be given after inspection of the Engineer to all surfaces other than those, which shall be subsequently polished or covered with laminated plastic sheet.

2.02.03 Surface Treatment

When shown on drawings or called for, decorative ply or laminated plastic sheets shall be bonded under pressure to the surface to be finished. The adhesive used shall be of brand and brought to site in sealed containers. The rate of application and the length of time for which the pressure is to be applied shall be as per the manufacturer's instructions. The edge of sheets shall be protected by teak lipping or bevelled as shown on drawings.

3.00.00 ACCEPTANCE CRITERIA

3.00.01 Door and Window Frames

All frames shall be square and flat at the time of delivery and shall be checked for dimensions and corner angles. After fixing they shall be on a fine vertical plane. All external door and window frames shall be caulked with mastic.

3.02.00 Door and Window Shutters

All doors and window shutters shall be of proper size, shape, and design and free of warp. When fixed to frames, these shall operate smoothly without jamming and all latching or locking devices shall engage properly without undue pressure.

3.03.00 Partitions, Panelling, Pelmets, Furniture, etc.

3.03.01 General

These shall conform to drawings in all details. No unsightly nail marks etc. shall be permitted. Plywood grains shall be matched to give a uniform and pleasing appearance.

3.03.02 Partition

Shall be checked for rigidity of fixing, plumb and horizontal as well as vertical alignment.

3.03.03 Pelmets

Shall be checked for rigidity of fixing and adequate clearance of fixture.

3.03.04 Cupboard Shutters

Shall operate smoothly without jamming and locks, bolts and double ball catches shall engage securely. Single ball catches shall not be used.

3.03.05 Drawers

Shall operate smoothly and have backstops to prevent them from being pushed too far. Locks shall engage securely.

3.03.06 Loose Furniture

When placed on a level surface, tables tops etc. shall be horizontal and the pieces stand stably on legs or supports.

4.00.00 IS CODES

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

IS: 848	-	Synthetic resin adhesives for plywood (Phenolic and Aminoplastic)
IS: 1003	-	Timber panelled and glazed shutters.
IS: 2191	-	Wooden flush door shutter (Cellular and hollow core type).
IS: 2202	-	Wooden flush door shutters (solid core type).
IS: 4021	-	Timber door, window, and ventilator frames.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall include of all activities mentioned in "Schedule of Item" for completion of the work. No separate payment shall be made for fixing, caulking, application of primer coat, polishing, providing of butt hinges, holdfasts, sliding/tower bolts, door stoppers, door closers and other fittings and fixtures.

5.02.00 Measurement

Measurement shall be done in Sqm for doors, windows, ventilators, shutters, partitions etc.

Measurement for wooden frame shall be in CuM.

Pelmets shall be measured in RM.

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SECTION – D

SUB-SECTION – D4

ROOF AND UNDERGROUND STRUCTURES WATER PROOFING, INSULATION AND ALLIED WORKS

SPECIFICATION NO. PE-TS-999-600-C004

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
1.00.00	SCOPE	3
2.00.00	INSTALLATION	3
3.00.00	ACCEPTANCE CRITERIA AND GUARANTEE	13
4.00.00	I.S. CODES AND STANDARDS	14
5.00.00	RATES AND MEASUREMENTS	15

ROOF AND UNDERGROUND WATER PROOFING, INSULATION AND ALLIED WORKS

1.00.00 SCOPE

This section covers furnishing, installation, repairing, finishing, curing, testing, protection, maintenance till handing over of roof and underground water-proofing, insulation and allied works for buildings and at locations covered under the scope of this package.

2.00.00 INSTALLATION

2.01.00 GRADING UNDERBED

The surface to receive the underbed shall be roughened and thoroughly cleaned with wire brush and water. Oil patches if any shall be removed with detergent. The surface shall be soaked with water and all excess water removed just before laying of the underbed.

The underbed shall not be laid under direct hot sun and shall be kept in shade immediately after laying so as to avoid quick loss of water from the mix and separation from the roof surface. The underbed shall be cured under water for at least 7 days.

The underbed shall be laid to provide an ultimate run off gradient not less than 1 in 120 and as directed by the Engineer. Upto an average thickness of 25mm the underbed shall usually be composed of cement and sand plaster. For higher thickness the underbed shall be made with cement concrete. The underbed shall be finished to receive the waterproofing treatment direct or insulation as the case may be.

2.01.01 Cement Mortar Underbed

The underbed grading plaster shall be average 25 mm thick maximum. It shall consist of cement and coarse sand in the ratio 1:4 nominal by volume. The sand and cement shall be thoroughly mixed dry and then water added. Each batch of mix shall be consumed before the initial set starts.

The plaster shall be fully compacted to the desired grade in continuous operation. The surface shall be even and reasonably smooth.

2.01.02 Cement Concrete Underbed

The underbed cement concrete shall be used where the subgrade is more than average 25 mm thick. It shall consist of cement concrete 1:2:4 nominal mix

by volume with 12 mm down stone chips and coarse sand. The aggregate shall be mixed dry and minimum quantity of water shall be added to make the mix workable.

The mix shall be laid to proper grade, fully consolidated and surface shall be smooth and even.

2.02.00 INSULATION

The Tenderer shall, along with the tender, send specifications of insulating materials he proposes to use and the proposed method of laying. Before bulk supply, the contractor shall send samples of insulating material to the Engineer, and after approval of the samples, the Contractor shall procure and transport the bulk material to the site. Whenever asked by the Engineer, the Contractor shall furnish test certificates from testing laboratory on the insulating and other properties of the materials.

After laying the insulation, the surface shall be made ready as required to receive the waterproofing treatment. If any plastering is used it shall be not leaner than 1:4 cement sand by volume and not thinner than 12 mm and it shall be cured for seven days.

2.02.01 Foam Concrete

This shall be of lightweight foam concrete of average 50 mm thickness or as specified or as shown on drawings. This may be laid in situ in suitable panels or precast blocks. The insulating properties shall be such that the thermal conductivity shall not exceed 0.125 Kcl/sq.m. hr degree C. Before starting the laying of foam concrete samples shall be prepared at site and got tested for approval of the Engineer.

The foam concrete laid shall be sufficiently strong to withstand the usual workload and standard loads expected on the roof. Any damaged portion shall be removed and replaced forthwith. Approval of the Engineer shall be taken before laying the waterproofing over the insulation.

While laying the foam concrete, samples from each batch of the mix shall be kept for test if so desired by the Engineer.

2.02.02 Expended Polystyrene Blocks

The expanded polystyrene block Insulation shall be fire retardant quality and shall have a maximum thermal conductivity of 0.026 Kcl m/sq.m h °C. It must be strong enough to withstand without any deformation under the workload and standard loads expected on the roof.

The Contractor shall lay the expanded polystyrene block as per manufacturer's approved specification. Only specifically experienced workers shall be used for this work. If the Engineer is not satisfied about the efficiency of the workers the Contractor shall secure manufacturers supervision at no extra cost to the Owner.

2.03.00 Fillets

Fillets at Junction of roofs and vertical walls shall be provided with the same insulating material as provided for the main roof insulation. The fillets shall be 150 mm x 150 mm in size unless otherwise shown on drawings or instructed by the Engineer.

Where there is no insulation over roof slab, fillets shall be cast-in-situ cement concrete (1:2:4) nominal mix volume.

2.04.00 Waterproofing Treatment

2.04.01 Bitumen Felt Treatment

Waterproofing treatment shall be laid by a specialist firm with long experience in the particular trade.

The waterproofing treatment for roofs with bitumen felts shall be done following relevant IS: 1346. Bitumen felt shall conform to IS: 1322 and Bitumen primer to IS: 3384.

The bonding materials shall consist of blown type conforming to IS: 702 or residual bitumen conforming to IS: 73 or a mixture of the two to withstand local conditions of prevailing temperature or gradient of roof surface. The Contractor shall convince the Engineer that the bonding material proposed to be used is suitable for the particular job.

The Contractor shall state the source from where he proposed to procure the materials. Samples of the self-finished felt shall be submitted in advance to the Engineer along with test certificates for his review. Test certificates for the bonding materials shall also be submitted and samples, if desired by the Engineer, shall be provided for confirmatory tests. Samples shall be submitted if instructed by the Engineer.

Minimum overlaps of 100 and 75 mm shall be given at the end and sides of strips of felt and properly bonded with bitumen. Joints in successive layers of felt shall be staggered.

Normal treatment with one layer of felt, heavy treatment with two layers of felt or Extra Heavy treatment with three layers of felt shall be indicated. Brief details of the various treatments shall be as follows:

a) Normal Treatment - Five courses

1) Primer coat conforming to IS:3384 applied at the rate 0.27lits/sqm min.

2) Hot applied bitumen at the rate of 1.2 kg/sq.m. (min.)

3) Hessian base self-finished felt, type 3, grade 1.

4) Hot applied bitumen at the rate of 1.2 kg/sq.m. (min.)

5) 20 mm thick pressed precast concrete tiles with 15 mm, thick 1:4 cement-sand mortar underbed.

b) Heavy Treatment - Seven Courses

With Hessian base felt

1) Primer coat conforming to IS:3384 applied at the rate 0.27lits/sqm min.

2) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)

3) Hessian base self-finished felt, type 3, grade 1.

4) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)

5) Hessian base self-finished felt, type 3, grade I.

6) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)

7) 20 mm thick pressed precast concrete tiles with 15 mm thick 1:4 cement: sand mortar underbed.

or

With fibre base felt

1) Primer coat conforming to IS:3384 applied at the rate 0.27lits/sqm min.

2) Not applied bitumen at the rate of 1.2 kg/sq.m (Min.)

3) Fibre base self-finished felt, type 2, grade 2.

4) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)

5) Fibre base self-finished felt, type 2, grade 2.

6) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)

7) 20 mm thick pressed precast concrete tiles with 15 mm thick 1:4 cement: sand mortar underbed.

c) Extra Heavy Treatment – Nine courses

With fibre based felt

1) Primer coat conforming to IS:3384 applied at the rate 0.27lits/sqm min.

2) Hot applied bitumen at the rate of 1.2 kg/sqm. (min.)

3) Fibre-base self-finished felt type 2, grade 1.

4) Hot applied bitumen at the rate of 1.2 kg/sq.m (min.)

5) Fibre base self-finished felt type 2, grade 1.

6) Hot applied bitumen at the rate of 1.2 kg/sqm. (min.)

7) Fibre base self-finished felt type 2, grade 1.

8) Hot applied bitumen at the rate of 1.2 kg/sqm. (min.)

9) 20 mm thick pressed precast concrete tiles with 15 mm thick 1:4 cement: sand mortar underbed.

or

With Hessian base felt

1) Primer coat conforming to IS:3384 applied at the rate 0.27lits/sqm min.

2) Hot applied bitumen at the rate of 1.2 kg/sqm. (min.)

3) Hessian base self-finished felt, type 3, grade 1.

4) Hot applied bitumen at the rate of 1.2 kg/sqm. (min.)

5) Hessian base self-finished felt, type 3, grade 1.

6) Hot applied bitumen at the rate of 1.2 kg/sqm. min.

7) Hessian base self-finished felt, type 3, grade 1.

8) Hot applied bitumen at the rate of 1.2 kg/sqm. min.

9) 20 mm thick pressed precast concrete tiles with 15 thick 1:4 cement: sand mortar underbed.

However, in special cases, more courses, or a combination of fibre base and hessian base felts may be asked for.

The surface to receive the waterproofing treatment must be cleaned and dried satisfactorily and the Engineer's approval taken before starting the work. If any existing waterproofing treatment is being augmented the existing top course shall be completely removed and all damaged felts or other defects repaired.

The Engineer may instruct the Contractor to lay part of the stipulated courses at the first instant to be followed later on with the balance courses. This interim finish shall be done with a course of hot applied bitumen. While doing the balance again hot bitumen shall be applied to start with after repair of all damages to the already laid course.

After completion the surface shall be cleaned taking care that felt cuttings etc. do not find their way into rainwater down comers.

2.04.02 Elastomeric Membrane

a) Material

The material shall consist of high solid content Polyurethane based cold liquid applied coatings as per ASTMC 836-89a comprising of urethane pre-polymers extended with flexible material, which cure by reaction with atmospheric moisture to give a continuous film which is rubbery and elastic or any other equivalent material permitted as per ASTM and approved by the Engineer. The material shall consist of high solid coating designed to give a high-build film. The material shall not be diluted. The coating shall have physical feature like high viscosity, 90% solids, high resistance to impact, abrasion and cracking, superior tensile strength, application limit of 70^0C minimum, 300%

elongation and forming a perfectly smooth permanently flexible seamless membrane which should have good adhesion to roof substrates (RCC, tiles, brick, and metals), having a minimum life of 10 years. It should also be resistant to acid (mild concentrated), alkali and have a very low water absorption rate (0.5%) max. at ambient temp. after 7 days.

The pack shall not be older than 9 months after the date of manufacture and packing.

b) Primer coat

It shall consist of polyurethane (P.U.) or any other equivalent material. Primer coat shall be a special blend of moisture curing urethane pre-polymers in solvent. A single coat of this primer shall be applied by brush over the prepared bed as an adhesion coat of an application rate of minimum 6 sq.m per litre.

The primer shall be allowed to dry for minimum of 2hrs. time before the successive finishing coats of P.U. liquid membrane is applied.

c) Finishing coats:

The finishing coats shall consist of two successive liquid coatings of high solids content urethane pre-polymers or equivalent material to form an elastomeric membrane. The overall dry film thickness shall be 1.5mm subject to minimum 500 gm per sq.m per coat application rate.

Each coat shall be allowed to dry for minimum 12 hours before applying the next coat. The surface should be dry and smooth before application.

The coating shall be continued up the parapets/walls for a minimum of 150mm over the finished roof surface. It shall be continued into rain water pipes by atleast 100mm.

The final coat of P.U. liquid when tacky shall be sprinkled with the sand.

For edges, expansion joints and any vulnerable points a later of polyscrim cloth /fabric to be embedded between 2 finishing coats.

d) Surface Finish:

Areas of roof treatment which are vulnerable to accidental damage shall be provided with wearing course consist of minimum 20 mm thick PCC of Grade M15 (using12.5mm size aggregate) cast in panel of maximum size of 1.20m x 1.20m and reinforced with 0.56mm diameter galvanised chicken wire mesh

and sealing of joints using sealant or elastomeric compound.

When the roof surface is subjected to foot traffic or used as a working area, a cement mortar (1:4) shall be applied over the top most layer of roofing treatment. Over this, a layer of chequered cement concrete flooring tiles conforming to IS:13801 shall be provided in place of stone grit and cement painted. The tiles shall be laid as per IS:1443.

2.04.03 Waterproofing by Epoxy Resin Based Application

Exposed surfaces of cement concrete, lime concrete or brickwork to be treated for waterproofing by the resin-based application shall be thoroughly cleaned and the epoxy resin based material to be applied as directed by the manufacturer. The material shall not have any adverse effect on the surface on which it is applied and must stick to it uniformly to make a strong durable bond. It shall not be affected by short duration fire, sun exposure, and light duty traffic. The application shall be resistant to growth of fungus and proof against saltpetre action. If desired by the Engineer, a sample shall be prepared in advance and tested for waterproofness for 48 hours under 300 mm depth of standing water. The Contractor shall arrange the demonstration by providing free the materials and labour for the application as free of cost to Owner. This item shall carry a guarantee as specified.

2.04.02 Flashing

Unless otherwise stated flashing shall be done in the same way as the waterproofing except that the last layer shall be finished with two coats of bituminous primer. The flashing shall be extended up the vertical surfaces as shown on drawing. The flashing shall end in grooves in vertical walls. The grooves shall be at least 65 mm deep and caulked with waterproof mastic cement. The minimum overlap with horizontal roofing felt shall be 100 mm.

Where specified or directed by the Engineer, metal flashing shall be provided. The materials shall be 18 Gage or 22 G G.I. sheets, as specified or as directed by the Engineer.

2.05.00 WATER-PROOFING OF UNDERGROUND STRUCTURES

Basements, ducts, pits, tunnels (excluding tanks) etc below the ground water table and in contact with soil are covered under this. Bonding material shall be blown bitumen of 65/25 grade conforming to IS: 702.

Waterproofing shall be provided on the outside of walls and top of RCC slab and shall be carried out upto 150mm above ground level. The number of layers of bitumen felt to be used for walls and floor unless otherwise shown in the drawing shall be:

a) 2 layers - for depths up to 5m below ground level

b) 3 layers - for depths beyond 5m below ground level

2.05.01 Method of laying the bitumen felts and workmanship shall be as per IS: 1609 and IS: 3067. Water proofing work shall be taken in hand only when the sub-soil water level is at its lowest; the site shall be kept dry by adequate arrangements for pumping out water till the work has been completed.

For this purpose, drains shall be formed along the edges of the excavation but beyond the building line, with suitable collecting sumps.

In case of large excavation areas where it is necessary to dewater under the floor, additional land drains shall be formed across the excavation, to adequately drain the area.

Adequate arrangement shall be made to protect the sides of excavation from slipping while the work is in progress.

The base concrete or mud-mat shall be rendered smooth by a 20mm thick sand-cement plaster (6:1). Any sharp edges/corners, over which the waterproofing course is to be laid, shall be eased out by means of cement.

The surface must be dry before the next operation is carried out.

Water proofing/damp proofing treatment:

A) Heavy Treatment (Two layers of felt)

i) Primer (For vertical faces only), as per I.S. 3384.

ii) Hot applied blown bitumen at the rate of 1.2 Kg/m2

iii) Hessian base, bitumen felt type 3 grades 2

iv) Hot applied blown bitumen @ 1.2 Kg/m2

v) Hessian base, bitumen felt type 3 grade 2

vi) Hot applied blown bitumen @ 1.2 Kg/m2

B) Extra Heavy treatment (Three layers of felt)

i) Primer (for vertical faces only) as per I.S. 3384

ii) Hot applied bitumen at the rate of 1.2 Kg/m2

iii) Hessian base bitumen felt type 3 grades 2

iv) Hot applied bitumen at the rate 1.2 Kg/m2

v) Hessian base bitumen felt type 3 grades 2

vi) Hot applied bitumen at the rate of 1.2 Kg/m2

vii) Hessian base bitumen felt type 3 grades 2

viii) Hot applied bitumen at the rate of 1.2 Kg/m2

The surface must be dry before the next operation is carried out at each stage said above.

The laying of felt over the bitumen so applied that it shall always commence on the floor, and shall be carried over to the walls only after treatment of the floor is complete. The minimum over lapping at sides and ends of strips shall be 10cm. Point for subsequent layers completely sealed by blow lamp.

A protective flooring of either brick flat in cement mortar (1:3) or 6cm thick cement concrete (M 15) or a coat of cement plaster (1:3) 4 cm thick shall be constructed over the bitumen layers to prevent damage to the latter during subsequent construction of the structural floor.

The walls shall be treated in a similar way; the bitumen felts joining at the base with the projecting felt laid over the mud-mat. The wall surface shall be made smooth where necessary with a coat of cement plaster (1:3), the felts laid as for the floor, ensuring that the surface to be treated is dry and then a protective brick wall, 12.5 cm nominal thickness shall be built in cement mortar (1:3) over the projecting mud-mat, the space between the wall and felt being grouted with cement.

3.00.00 ACCEPTANCE CRITERIA AND GUARANTEE

The surface level shall be such as to allow quick draining of rains without leaving any pool anywhere. The finishing course shall be fully secured and shall have an even density. There shall not be any bubble formation or crushed or squeezed insulation or underbed.

The contractor shall give a guarantee in writing for all works executed under this specification supplemented by a separate and unilateral guarantee from the specified agency for the roof waterproofing treatment work. The guarantee shall be for materials and workmanship as under:

For Bitumen Felt Treatment under clause no. 2.04.01: 5 years in case of normal treatment, 10 years for heavy treatment and 20 years for extra heavy treatment.

For Elastomeric Membrane under clause no. 2.04.02: 10 (ten) years.

In case guarantee is more stringent in owner specification, more stringent guarantee shall be applicable. The mode of execution of the guarantee shall be such, which shall be acceptable to the Owner.

4.00.00 I.S. CODES AND STANDARDS

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

a)	IS: 73	-	Paving Bitumen
b)	IS: 702	-	Industrial Bitumen
c)	IS: 1203	-	Methods of testing tar and bitumen
d)	IS: 1322	-	Bitumen felts for waterproofing and damp proofing.
e)	IS: 1346	-	Code of practice for waterproofing of roofs with bitumen felts.
f)	IS: 1609	-	Damp-proofing Treatment using Bitumen Felts – Code of Practice
g)	IS: 3067	-	Code of practice for General design details and preparatory work for Damp-proofing and water-proofing of buildings
h)	IS: 3384	-	Bitumen primer for use in waterproofing and damp proofing.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall be for complete work, including the cost of all materials and labor, as detailed in the specification unless any portion is specifically excluded in the "Schedule of Items".

No extra shall be paid for finishing around opening, sleeves, pipes, ducts, inserts, etc.

No separate payments shall be made for cleaning of surface, treating of cracks and surface preparation.

5.02.00 Measurement

The finished work shall be measured in Sqm of actual surface area for the purpose of payment.

No deduction shall be made and no extra shall be paid for openings upto 0.4 sqm.

VOLUME: II B

SECTION - D

SUB-SECTION – D5

METAL DOORS, WINDOWS, VENTILATORS, LOUVERS ETC.

SPECIFICATION NO. PE-TS-999-600-C005

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
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ATTACHMENT

ANNEXURE – A	SCHEDULE OF FIXTURES	12

METAL DOORS, WINDOWS, VENTILATORS, LOUVERS ETC.

1.00.00 SCOPE

This section covers supplying and/or erecting and installing of all metal doors, windows, ventilators, louvers, glazed partitions, etc. The scope of work shall also include the assembly and erection of all doors, windows, louvers, glazed partitions, etc. Supplying and/or fixing of all door and window accessories and hardware are also included in the scope.

2.00.00 INSTALLATION

2.01.00 Materials

Steel sections used for fabrication of doors, windows etc. shall be standard rolled steel sections specified in IS: 1038 and IS: 1361 or as specified.

Steel sheets for frames, shutters, louver blades etc. shall be of gauge mentioned in drawings and schedules.

Aluminium sections for fabricating doors, windows, partitions etc. shall be extruded sections conforming to IS:733 or IS:1285 or as manufactured by Indian Aluminium Company Limited or approved equivalent. Aluminium door, windows and ventilator shall be fabricated as per IS:1948 and IS:1949. The alloy used shall conform to IS Designation HE 9-WP of IS: 733.

Hardware and fixtures shall be as specified and the best quality from approved manufacturers shall only be used. The tenderer shall specifically state the particular manufacturer's materials he proposes to use. Improper alignment or faulty operation due to inadequate strength of hardware or fixture shall entirely be the Contractor's responsibility.

All hardware and fixtures shall be able to withstand repeated use. Door closures shall conform to IS: 3564 and shall be suitable for doors weighing 61-80 Kg. unless otherwise stated. Each closer shall be guaranteed against manufacturing defect for one year and any defect found within this period shall be rectified or shall be replaced free of charge. Concealed door closers shall be either floor mounted or transom mounted, suitable for installation with metal doors. It shall conform to the performance Requirements and endurance test stated in IS: 3564 - Appendix-A. The Contractor shall submit samples of each type of hardware to the Engineer. The approved samples shall be retained by the Engineer for comparison of bulk supply. The samples shall be returned to the Contractor towards end for incorporation in the job. The mastic for caulking shall be of best quality from a manufacturer approved by, the Engineer. In general, mastic for fixing of metals frames shall be as per IS: 1081 or as approved by the Engineer.

2.02.00 Fabrication

2.02.01 Steel Doors, Windows, Ventilators, louvers etc.

a) Door Frames

Frames shall be fabricated from 16 gage(G) sheets. They shall, be mortised, reinforced, drilled, and tapped for hinge lock and bolt strikes. Where necessary, frames shall be reinforced for door closers. Welded construction with mitered Corners shall be used. Rubber door silencers shall be furnished for the striking jamb. Loose "T" masonry anchors shall be provided. Frames shall finish flush with floor and adjustable floor anchors shall be installed. Frames shall be brought to site with floor ties/weather bars installed in, place.

b) Double Plate Flush Door Shutters

Door shutters shall be 45 mm thick, completely flush design and shall comprise of the outer sheets or 18 G steel sheets, rigidly connected and reinforced inside with continuous vertical 20 G stiffeners, spot welded in position at not more than 150 mm on centres.

Both edges of doors shall be joined and reinforced full height by steel channels placed immediately inside and welded to the door faces. Top and bottom of doors shall be reinforced horizontally as shown on drawing by steel channels running full width of door. Doors shall not have more than 2.5 mm clearance at jambs and heads, shall have proper level on lock stiles and rails to operate without binding, and shall be reinforced at corners to prevent sagging or twisting. Pairs or double doors shall have meeting-stile edges bevelled or rebated. Where shown on drawing, or called for in the schedule of items, the doors shall be sound deadened by filling the inside voids with mineral wool or other suitable approved materials.

Doors shall be mortised, reinforced, drilled, and tapped in shop for hinges, locks, and bolts. They shall also be reinforced for closers, push-plates, and other surface hardware's where necessary. Any drilling and tapping required for surface hardware shall be done at site. Where shown drawing, provision shall be made for fixing glazing, vision panels, louvers etc. glazing mouldings shall be of 18 G steel or extruded aluminium sections and suitable for fixing 6 mm. glass. Louvers blades shall be V or Z shaped and made out of 16 G sheets.

c) Single Sheet Door Shutters

Single sheet doors shall be made from best quality 18 G mild steel sheets, and shall present a flush surface on the outside. The inside shall be stiffened with semi tubular edge and central stiffening rail, which shall convey the lock and other fixture. The frames shall be made from best quality, 16 G mild steel sheets.

Wherever required, provisions for fixing glass panes, louvers etc. shall be made.

The manufacturing shall be done as specified in 2.02.01 (b) “Double Plate Flush Door Shutters.”

d) Sliding Door

Sliding doors shall be either double plate or single plate Construction made out of 18-gauge steel sheets with adequate stiffeners. The contractor shall specify the weight of the door in his shop and submit the manufacturer's catalogue of the sliding gear he proposes to use. Where called for the Contractor shall make provision for openings to the door for monorail beams. Doors shall close positively to exclude rainwater from seeping in. When called for, sliding doors shall withstand specified wind loads without buckling or jamming. The door shall slide freely under all ambient conditions.

e) Door Threshold

Door threshold shall be provided. Doors without threshold shall have bottom tie of approved type.

f) Steel Windows, Sashes, and Ventilators etc.

These shall conform in all respects to IS: 1038 and IS: 1361 latest editions. The details as called for in the above codes shall be applicable for coupling mullions, transoms, weather bars, and pivot arrangements for ventilators, etc. or as called for. All welds shall be dressed flush on all exposed and contact surfaces. Where composite unit openings are required the individual window units shall be joined together with requisite transoms and mullions. All windows shall be outside glazed, fixed with putty or metal glazing beads as specified. Where aluminium glazing beads are specified, they shall be extruded aluminium channel 9.5 mm x 9.5 mm x 1.6 mm (Jindal Section No. 2209) unless otherwise shown on drawings. Aluminium beads shall be given one coat of zinc chromate primer before fixing to windows.

2.02.02 Aluminium Door, Windows, and Frames

Extruded sections shall have a minimum 3 mm wall thickness. All sections shall be approved by the Engineer before fabrication is taken up. Doors frames, mullions, transom etc. shall be anodized in a bath of sulphuric acid to provide a clear coating of minimum 15-micron thickness. The anodized materials shall then be sealed by immersing in boiling water for 15 minutes. A protective transparent Coating shall be applied to the sections before shipment from the factory.

All work shall be fitted and shop assembled to a first class job, and ready for erection. Shop joints shall be made to hair lines and then welded or braced by such method as will produce a uniform colour throughout the work. Work on the above, other than described, shall be carefully fitted and assembled with neat joints with concealed fasteners. Wherever possible, joints shall be made in concealed locations and on edges of doors. Field connections of all work may be made with concealed screws or other approved type of fasteners. Glazing beads shall be snap fit type without visible screws and shall be of sizes to accommodate 6 mm thick glazing. All work shall be adequately braced and reinforced as necessary for strength and rigidity.

2.03.00 Shop Coat or Paint

The shop Paint for steel doors, windows etc. shall be best lead or zinc chromate primer paint from, approved manufacturer. All surfaces shall be thoroughly cleaned of rust, grease, loose mill scales etc. and given one coat of shop paint. Portions like mullions, transoms etc. that will be inaccessible after assembly of units shall be given an extra coat of paint before assembly.

Where called for, all steel doors, windows, etc. shall be hot dip galvanized to give a coating weight of 1½ - 2 oz. per sqft. One coat zinc chromate primer coat shall then be applied as shop paint.

Portions of aluminium frame, which come in contact with masonry construction shall be (before shipment from workshop) protected with a heavy coat of alkali resistant paint. Aluminium coming in contact with other incompatible metals shall be coated with zinc chromate primer.

2.04.00 Handling & Storage of Fabricated Material

All metal doors, windows, etc. shall be packed and crated properly before dispatch, to ensure that there will be no damage to the fabricated materials. Loading into wagons and trucks shall be done with all care to ensure safe arrival of materials at site in undamaged condition.

When taking delivery of items supplied by Owner, the Contractor shall satisfy himself that the items supplied are up to the specified standard. Any defect detected shall promptly be brought to the notice of the Engineer.

All metal doors, windows etc. shall be stored under cover in a way to prevent damage or distortion. Special care shall be taken to prevent staining of aluminium products by rust, mortar etc.

2.05.00 Assembly & Erection at Site

In general, the fixing of steel doors, windows, ventilators, louvers, etc. shall conform to IS: 1081. The Contractor shall assemble and install all steel doors, windows, sashes, fixed metal louvers, etc. including transoms and mullions for composite units in respective places, keening proper “Lines and levels”, and in approved workmanlike manner, to give trouble free and leak-proof installations. Installation shall be done according to instructions of the manufacturer, and/or as approved by the Engineer. If required by the Engineer, the installation shall have to be carried out under the supervision of the manufacturer's staff. The Contractor shall take all precaution against damage of the components during installation. Necessary holes, chases, etc. required for fixing shall be made by the Contractor and made good again as per original, after installation, without any extra charge.

After installation of steel doors, windows, etc. all abrasions to shop-coat of paint shall be retouched and made good the same quality of paint used in shop coat.

All coupling mullions, transoms, frames, etc. in contact with adjacent steel and other members, shall be well bedded in mastic. The Contractor shall bring to the site the cement in original sealed containers of manufacturer and shall apply it as per the instruction. For all frames supplied by either the owner or the Contractor, mastic shall be supplied by the Contractor and caulking done properly as per drawings, specifications and as per instructions of the Engineer.

Door shutters, partitions hardware fixtures etc. shall be fixed only after major equipments have been installed in rooms.

Wherever required, nylon cords of approved quality shall be supplied along with pivoted sashes and shall be of adequate length to terminate one meters from the floor. Loose ends of cords shall end in metal or plastic pull as approved by the Engineer.

2.06.0 Fire proof Door

Fire proof doors shall be provided at all fire exit points as specified and also to restrict the spread of fire within buildings whether from internal fire or from external fire. The construction details of door shall conform to the requirements stipulated in IS:3614 (Part-1). Doors shall comply with the testing requirement mentioned in IS:3614 (Part-2). The doors shall be approved by Tariff Advisory Committee and shall have minimum 2 hrs. fire rating.

Metal covered (on both sides) Doors having insulating core filled up with mineral wool shall be used at all fire exit points and shall open outside.

All necessary accessories and hardware shall also be supplied along with doors. Fire proof door shall be provided with zinc silicate primer (minimum DFT 75 micron) after blast cleaning the surface to near white metal surface and shall be finished painted with epoxy based painting.

3.00.00 ACCEPTANCE CRITERIA

3.01.00 For fabricated Items

a) Overall dimensions shall be within ±1.5 mm of the size shown on drawings.

b) Mullions, transoms etc. shall be in one length and permissible deviations from straightness shall be limited to ±1.5 mm from the axis of the member.

c) Door and window shutters shall operate without jamming. The clearance at head and jamb for door shutters shall not exceed 1.5 mm for double leaf doors; the gap at the meeting stiles shall not be more than 1.5 mm.

d) Door leaves shall be undercut where shown on drawings.

e) Doors, windows, frames, etc. shall be on a true plane, free from warp or buckle.

f) All welds shall be dressed flush on exposed and contact surfaces.

g) Correctness of location and smoothness of operations of all shop installed hardware and fixtures

h) Provision for hardware and fixtures to be installed at site.

i) Glazing beads shall be cut with mitered corners.

j) Glazing clips, fixing devices etc. shall be supplied in adequate numbers.

k) Shop coats shall be properly applied.

l) Exposed aluminum surfaces shall be free from scratches, stains, and discoloration. Anodized surfaces shall present a uniform and pleasing look.

3.02.00 For installed Items

a) Installations shall be at correct location, elevation and in general, on a true vertical plane.

b) Fixing details shall be strictly as shown on drawings.

c) Assembly of composite units shall be strictly, as per drawings with mastic caulking of transoms and mullions, gaskets, weather strips etc. complete.

d) All frames on external walls shall be mastic caulked to prevent leakage through joint between frames and masonry.

e) All openable section shall operate smoothly without jamming.

f) Locks, fasteners etc. shall be engage positively. Key shall, be non-interchangeable.

g) Cutting to concrete or masonry shall be made good and all abrasions to shop paint shall be touched up with paint of same quality as shop paint.

h) Aluminium doors, windows, etc. shall be free from scratches stain or discoloration.

4.00.00 INFORMATION TO BE SUBMITTED

4.01.00 With Tender

a) Names of manufacturers for Doors, windows etc.

b) Manufacturer's catalogue for all hardware and fixtures proposed to be used.

4.02.00 After Award

a) Before starting fabrication of all metal doors, windows, etc. the Contractor shall submit detailed fabrication drawings to the Engineer for approval. The fabrication shall be started only after approval of drawings.

b) He shall submit a programme of work to be done for the approval of the Engineer.

c) Before bulk supply, he shall submit for the approval of the Engineer samples of all bought out items and samples of each type of fabricated items. The samples shall by retained by the Engineer for comparison of bulk supply and returned to the Contractor towards the end for final incorporation in the job.

5.00.00 IS CODES

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

Specification for Wrought Aluminium and Aluminium Alloy bars, rods and sections (for general engineering purpose)	-	IS: 733
Specification for Wrought Aluminium and Aluminium Alloy, extruded round tube, hollow section (for general engineering purpose)	-	IS: 1285
Steel doors, windows, and ventilators	-	IS: 1038
Steel windows for industrial, building	-	IS: 1361
Aluminium doors windows, and ventilators	-	IS: 1948
Aluminium windows for industrial buildings	-	IS: 1949
Steel doorframes	-	IS: 4351
Code of practice for fixing and glazing of Metal (steel and aluminium) doors, windows and Ventilators.	-	IS: 1081
Specification for Fire-check Doors – Part 1: Plate, Metal covered and Rolling type	-	IS: 3614
Hot Rolled Steel Sections for Doors, Windows and Ventilators – Specification	-	IS: 7452

6.00.00 RATES AND MEASUREMENT

6.01.00 Rates

Rates shall be applicable of all elevation. Rates shall include preparation of working drawings (if required), supply of material, fixtures, gaskets, erection of unit, caulking and jamming of frames, including cutting/drilling/welding, grouting, grinding, making good of the structure for installing the unit etc. complete as per “Schedule of Items”.

Rates shall also include cost of surface preparation, application of primer, enamel painting or anodizing as applicable.

Rate for fire proof door is inclusive of providing insulation core, primer, shop painting (epoxy based), all hardware as specified in Schedule of items.

6.02.00 Measurement

Supply and installation of doors, windows, and ventilators shall be measured in Sqm or Kg as per BOQ item. If measured in sqm, it shall be for net outer to outer (excluding frame) area of doors, windows, and ventilators of each type used as described in “Schedule of Items”. Frame for steel or aluminum shall be measured in Kgs. Wooden frames shall be measured in Cum. Measurement for aluminum partition frames shall be in Kg. Paneling and glazing shall be paid separately if not covered in BOQ item description.

Measurement for fire proof door shall be in Sqm in net area outer to outer of the door.

ANNEXURE-A

SCHEDULE OF FIXTURES

A. TIMBER DOORS

1. For single leaf panel/flush doors

   i) 100 mm brass butt hinges with screws - 3 Nos.

   ii) 150 mm brass tower bolts with screws - 1 No.

   iii) 100 mm x 225 mm clear plastic push Plate with counter sunk brass screws - 1 No.

   iv) 30 mm brass ring pull handle with Plates and screws - 1 No.

   v) 150 mm brass coat hook with screws - 1 No.

   vi) Heavy duty, cylinder looks on active leaf - for flush door. For door-closure, see "Door Schedule".

B. ALUMINIUM DOORS

1. For double leaf door

   i) Concealed hanging arrangement for door leaves.

   ii) Concealed two points bolt encasing simultaneously at head and threshold on inactive leaf, operable from inside.

   iii) Heavy duty, cylinder look on active leaf.

   iv) Pull handle of approved design on both leaves.

   v) Doors stops for both leaves.

   vi) Overhead door closure for both leaves.

ANNEXURE-A

C. STEEL DOORS AND WINDOWS

1. Doors

a) Double leaf doors

i)	100 mm butt hinges	- 3 Nos. on each leaf.
ii)	300 mm aluminum tower bolt	- 2 Nos. (top and bottom) On inside of inactive Leaf. 1. No. (Top only) On inside active leaf.
iii)	200 mm anodized aluminum pull handle	- 1 No. of each leaf.
iv)	Door stop of approved design	- 1 No. of each leaf.

NOTE: For locks, door closure and threshold, see "Door Schedule".

b) Single leaf doors

i)	100 mm butt hinges	- 3 Nos.
ii)	300 mm aluminum tower bolt	- 2 Nos. top & bottom of Inside face
iii)	200mm anodised aluminum Pull handle	- 1 No.
iv)	Door stop of approved design	- 1 No.

NOTE: For locks, door closures and threshold, see “Door Schedule".

2. Windows, Ventilators, etc.

a) Side Hung Windows

i)	Hinges	- As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.
ii)	12" peg stays	- 1 No. per leaf

iii) 2 point handles - 1 No. per leaf

b) Top Hung Ventilators (Projecting Out)

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) Adjustable sliding fabrication assembles - 2 Nos. per leaf.

iii) 2 point handles - 1 No. per leaf.

c) Bottom Hung Ventilators (Projecting in)

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) Concealed side arms for opening adjustment. - 2 Nos. per leaf.

iii) Spring Catch - 1 No. per leaf.

ANNEXURE-A

D. ALUMINIUM WINDOW, VENTILATORS, ETC.
(As per IS-1948 latest editions)

a) Side Hung Windows

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) 300 mm peg stays - 1 No per leaf

iii) 2 point handles - 1 No per leaf

b) Top Hung Ventilators (Projecting out)

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) Adjustable sliding fabrication assembles - 2 Nos. per leaf

iii) 2 Point handles - 1 No. per leaf

c) Bottom Hung Ventilation & (Projecting In)

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) Concealed side arms for opening adjustment - 2 Nos. per leaf

iii) Spring Catch - 1 No. per leaf

VOLUME: II B

SECTION - D

SUB-SECTION – D6

GLASS AND GLAZING

SPECIFICATION NO. PE-TS-999-600-C006

Maharatna Company

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
1.00.00	SCOPE	3
2.00.00	INSTALLATION	3
3.00.00	ACCEPTANCE CRITERIA	4
4.00.00	I.S. CODES	4
5.00.00	RATES	5

GLASS AND GLAZING

1.00.00 SCOPE

This section covers supplying and fixing of all glass and glazing including all clips, putty, mastic cement etc. wherever required as per specifications.

2.00.00 INSTALLATION

2.01.00 General

The Contractor shall supply and install all glass and glazing as required for various doors, windows, sashes, ventilators and fixed louvers, miscellaneous glazing and partitions, from approved manufacturer like Hindustan Pilkinton or equivalent, having uniform refractive index and free from flaws, specks, and bubbles. The glass shall be brought to site in the original packing from the manufacturer and cut to size at site.

Materials:

a) Glare reducing or beat absorbing glass shall be "Calorex" of Hindustan Pilkinton or approved equivalent and special care shall be taken to grind smooth and round off the edges before fixing.

b) Clear glass shall be flat draw sheet glass and shall be at least 4 mm thick. Sheet glass for doors shall be minimum 5.5 mm thick.

c) Wired glass shall be thick- rolled glass with centrally embedded 42g wire mesh of Georgian type. This may be of clear or coloured glass, as required.

d) Obscure glasses shall have a cast surface in one side.

e) Coloured and figured glass shall be as per approved sample.

f) In general, the putty shall conform to IS: 400 and be of best quality from approved manufacturer. It shall be brought to site in the manufacturer's original packing.

g) Neoprene gaskets with snap-fit glazing beads shall be fixed as per manufacturer's instructions and shall sit snugly against glass to give a leak proof installation.

2.03.00 Glazing, Setting, and Finish

All glazing clips, bolts, nuts, putty, mastic cement etc. as required shall be supplied by the Contractor.

All glass shall be thoroughly cleaned before putting in position. Each glass pane shall be held in place by special glazing clips of approved type. As specified in relevant I.S. Codes, four glazing chips shall be provided per glass pane, except for large panes were six or more clips shall be used as per engineer's instructions. All holes that may be necessary for holding the clips glazing heads and all other attachments shall be drilled by, the Contractor.

Glass panes shall be set without springing, and shall be bedded in putty and back puttied, except where mouldings or gasket are specified, putty, mastic cement etc. shall be smoothly finished to the even line and figured glass shall be set with smooth side out.

Where owner will supply glass, the Contractor shall cut it to size and fix them in the same as specified above.

The Contractor shall supply necessary glazing clips, putty, mastic cement etc.

After completion of glazing, the Contractor shall remove all dirt stains, excess putty etc. clean glass panes and leave the work in perfectly acceptable condition. All broken cracked or damaged glass shall be replaced by new ones at the contractor’s own cost.

3.00.00 ACCEPTANCE CRITERIA

a) All installation shall be free from cracked, broken, or damaged glass. Edges of large panes of thicker glass and heat absorbing glass shall be inspected carefully for chipped, cracked, or underground edges.

b) Glazing shall be carefully done to avoid direct contact with metal frames.

c) All glass shall be embedded in mastic or fixed by neoprene gaskets to give a leak proof installation.

d) At completion, the panes shall be free from dirt, stains, excess putty etc. to the complete satisfaction of the Engineer.

4.00.00 I.S. CODES

Following are some of the important I.S. Codes relevant to this Section:

IS: 3548 - Code of practice for glazing in building.

IS: 1081 - Code of practice' for fixing and glazing metal doors, windows ventilators.

5.00.00 RATES

Rates of glass and glazing if not included in respective items for supply and installation of window, ventilator, and partitions shall be paid separately as per BOQ items provided. No separate payment shall be made for glazing clips, mastic cement, putty, screws; rails, etc. nor for drilling holes in frames for inserting glazing clips.

VOLUME: II B

SECTION - D

SUB-SECTION – D7

ROLLING STEEL SHUTTERS AND GRILLS

SPECIFICATION NO. PE-TS-999-600-C007

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
1.00.00	SCOPE	3
2.00.00	INSTALLATION	3
3.00.00	ACCEPTANCE CRITERIA & GUARANTEE	5
4.00.00	I.S. CODES	5
5.00.00	RATES AND MEASUREMENTS	5

ROLLING STEEL SHUTTERS AND GRILLS

1.00.00 SCOPE

This Section covers the design and supply of materials, fabrication, delivery and erection of Rolling Shutters/Grills with motor drive and/or manual operation including all accessories as hereinafter specified.

2.00.00 INSTALLATION

2.01.00 Components

a) Slats for rolling shutters shall be made from tested bright cold rolled, annealed M.S. strips, not less than 0.9 mm thick for shutters upto 4.5 M wide and not less than 1.25 mm thick for shutters having width more than 4.5 M, wide and above, machine rolled at 75 mm rolling centers, interlocking with each other. The profile will be such as to prevent excessive deflection under specified wind load.

b) Rolling grills shall be constructed out of 6mm rods at 35 mm on centers running horizontally flexible connected with vertical links spaced not more than 200 centers. Alternatively, rolling grills shall be made from perforated slats of approved design reinforced with 6mm dia. rods.

c) End locks shall be heavy type M.C.I./C.I. and shall be provided at each end of alternate slats unless specified otherwise.

d) Bottom bars shall be finished with two angles not less than 6 mm thick for external shutters. When shown on drawings, a flexible weather strip shall be applied to make tight contact with the floor.

e) Guides shall be of such depth as to retain the shutter under a wind pressure of 100 Kg/Sq.m.

f) Shafts shall be of steel pipe of sufficient size to carry the tensional load with a maximum deflection of 1/360th of span. Grease packed ball bearings or bushings shall be provided for smooth trouble free operation.

g) Hoods shall be formed of not less than 20-gauge steel, suitable reinforced to prevent sag.

h) Locks shall be slide bolt and hasp, or cylinder lock operable from one or both sides. Provision securing hand chain with pad-lock, provision for removable handle for hand cranks etc. shall be made as prescribed by the Engineer.

i) Power unit shall be suitable for 3 phase, 50 cycles, 400-volt A.C. power supply and be either floor or wall mounted unit. The motor shall be of sufficient capacity, to move the shutter in either direction at a speed of 0.3 metres per second. In addition to the gear motor each standard power unit shall include a magnetic brake, a reversing starter with built-in overload protection, a geared limit switch and one push button station located inside the building unless otherwise stated in drawing.

It is desirable that the bottom bar of motor operated doors shall be provided with a sensitive edge, electrically connected to stop the travel of the door on meeting an obstruction.

j) Operating chains shall be of tested quality, heavily galvanized and with all ends rounded to assure smooth operation and hand protection.

k) Reduction gears shall be high strength grey cast iron, machine moulded from machine out patterns.

2.02.00 Manually Operated Shutters/Grills

Manually operated shutters shall be easily operable by one person. The speed of operation shall be about 1.3 metres per second. In general, manually operated shutters shall be push pull type for opening up to 9 Sq. metre in area. Larger shutters shall, be either chain and gear operated or crank and gear operated. The crank handle shall be removable. All shutters shall be lockable from one or both sides as desired by the Engineer.

2.03.00 Power operated Shutters/Grills

These shall be operable from a push button station conveniently located beside the door. One emergency hand chain/crank operation shall also be provided for use in case of failure of the electric system. Where called for, externally mounted shutters shall be operated by control mechanism located inside the building.

2.04.00 Shop Coat

Shutters shall be painted with one coat of red lead or zinc chromate primer. Where specified, doors shall be galvanized and subsequently painted one coat of zinc chromate for adhesion of field coat.

2.05.00 Erection

Door shall be installed by the manufacturer or his authorized representative and all work shall be as per manufacturer's instructions. Any drilling or cutting to concrete, masonry etc. shall be made good after erection of shutters

and all abrasion to shop coat shall be touched up. All electrical work shall be in strict accordance with the latest Indian Electricity Rules.

3.00.00 ACCEPTANCE CRITERIA AND GUARANTEE

3.01.00 Shop Inspection

After completing the manufacture of the different components of the rolling shutter, an arrangement for shop inspection by the Engineer shall be made to check the conformity with approved shop drawings.

3.02.00 Field Inspection

After installing the shutters, the Contractor shall test the performance of the shutter in the presence of the Engineer. The doors shall be smoothly operable under all ambient conditions. All control and locking devices shall give fault free performance.

3.03.00 Guarantee

The Contractor shall give one year's guarantee for the successful operation of the shutters. This shall be supported by a separate and unilateral guarantee from the manufacturer of the shutters.

4.00.00 I.S. CODE

IS: 6248 - Metal rolling shutters and rolling grills.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates for rolling shutters and grill shall include the cost of the locks, guide channels, cost of drive as specified. In case of electrically operated rolling shutters, the rate shall also include the mounting of controls, wire and wiring from the nearest junction box, conduit and other electrical connections and cost of electric motor.

5.02.00 Measurement

Supply and installation of rolling shutter and grill shall be measured in Sqm in net outer to outer (including frame) area of each type used as described in “Schedule of Items”.

VOLUME: II B

SECTION - D

SUB-SECTION – D8

MISCELLANEOUS METAL

SPECIFICATION NO. PE-TS-999-600-C008

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
1.00.00	SCOPE	3
2.00.00	INSTALLATION	3
3.00.00	ACCEPTANCE CRITERIA	7
4.00.00	IS CODES	8
5.00.00	RATES AND MEASUREMENTS	8

MISCELLANEOUS METAL

1.00.00 SCOPE

This section covers supply, fabrication and erection of miscellaneous metal items of light nature in gates, balcony and stair hand rails, structural works, ladders, hangers, masonry anchors, anchor bolts, fasteners, chain link fencing, barbed wire fencing etc. as specified or shown on drawing or as instructed by the Engineer. The above items shall be of fabricated or cast of mild steel, aluminium, brass, cast iron, M.S.& galvanized M.S. sheets, aluminium sheets, expanded metal, wire mesh as shown on drawings or specified.

2.00.00 INSTALLATION

2.01.00 Fabrication/casting

2.01.01 General

All work shall be done according to approved shop drawings. All workmanship shall be equal to the best practice in modern structural or foundry shop.

2.01.02 Shop Connections

a) All shop connections shall be riveted or welded except when noted otherwise on drawings.

b) Welding of steel shall be done in accordance with IS: 816.

c) Welding of aluminium shall be done accordance with IS: 2812, “Arc welding of Aluminium and Alloys.” Special care shall be taken to grind smooth all welded surface that shall remain exposed to view. Welds shall be electrically continuous if so required by the Engineer.

2.01.03 Shop Coat

Before leaving the shop, all metal work shall be thoroughly cleaned by effective means of all loose mill seals, rust and foreign matter. Except where encased in concrete, all steelwork shall be given one coat of approved metal protective paint, applied be brush thoroughly and evenly, well worked into joints and other open spaces. All paint shall be applied to dry surfaces. When specified steel work shall be galvanised or painted with a coat of zinc chromate primer. Aluminium surfaces, which shall come in contact with masonry, shall be given one coat of bituminous paint.

2.02.00 Erection

2.02.01 Bracing

The Contractor shall provide all necessary temporary guys and braces to ensure alignment and stability of the members and to take care of all loads to which the structure may be subjected, including erection of equipment and operation of the same.

2.02.02 Temporary Bolting-Up

As erection proceeds the Contractor shall plum up and level all members and shall securely bolt up to take care of all dead load, wind load and erection stresses. Wherever erection equipment or other loads are carried by members during erection, proper provision shall be made to take care of the stresses resulting from the same.

2.02.03 Turned Bolt

For field connections where bolting is specified, holes for the turned bolts may be reamed in the field, if required. All drilling or reaming for turned bolts shall be done after the parts to be connected are assembled.

2.02.04 Welding

Where specified on drawings, welding shall be done in accordance with IS: 816 for steel and IS: 2812 for Aluminium & Alloys.

2.02.05 Cutting and Fitting

No cutting of sections, flanges, webs of angles shall be done without the approval of the Engineer. Where indicated on the drawings holes, cuttings, etc. shall be provided as required for installation, to the work by the other Contractors. No additional holes or cuttings, then those shown on drawings, shall be made without the approval of the Engineer.

2.02.06 Drifting

Correction minor misfits and a reasonable amount of reading and cutting of excess stock from rivets may be permitted. For this, light drifting may be allowed to draw holes together. Twist drills shall be used to enlarge as necessary to make connections, reaming that weakness the members or make it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins or a moderate amount or reaming and slight chipping and cutting shall immediately be called to the attention of the Engineer-and approval of the method of correction obtained. The use of cutting torches to enlarge or alter rivet holes shall not be permitted.

2.02.07 Spot Painting

All field rivets and bolts and also any serious abrasion to shop paint shall be spot painted with the same materials and used for the shop paint or equivalent.

2.02.08 Good

All cutting to concrete or masonry shall be made good to the satisfaction of the Engineer.

2.02.09 Grouting

All bearing plates, loose, lintels and beams, etc. shall be set to proper grade and level by the Contractor and the Engineer's approval obtained before proceeding with the grouting. Grouting shall be done in 1:1½:3 concrete with 6 mm down stone chips or as specified in schedule of items.

2.02.10 Anchor Fasteners

The anchor fasteners shall be of two type viz. light duty for carrying tensile load upto 0.5MT per fasteners and heavy duty for carrying tensile load of 0.5MT to 5.0MT per fasteners. These anchor fasteners shall be fixed into concrete. The Contractor shall submit the Manufacture’s literature showing the average pull out and average shear value for anchor of various sizes. Anchors shall be fixed in position strictly as per the manufacturer’s instructions and as approved by the Engineer.

Heavy Duty Anchor Fasteners

The safe tensile load carrying capacity of the anchors shall be arrived by providing the minimum factor of capacity of 2.5 for the characteristic load of the anchor. Minimum size of anchor shall be M8 (8mm). All anchors shall be from the approved manufacturers like HILTI or equivalent.

a) Anchor fasteners shall be supplied and fixed in position by the contractor. Anchor fasteners can be of mechanical bonding or chemical bonding.
b) Capacity of the anchor shall be established after considering the effect of concrete grade, embedment depth, concrete thickness, anchor spacing and edge distance from the concrete edge.

c) The selection for the particular type of bonding for the anchors shall be made after considering the concrete grade, available embedment depth, load to be transferred, space available for installing anchors.
d) The mechanical bonding anchor are torque controlled anchors made from carbon steel of grade 8.8 as per IS:1367 part 3. Anchors in bolt as well as nut version are acceptable. The bolt version anchors consist of bolt washer, sleeves, plastic section, expansion sleeves and a cone. Nuts version anchor consists of nuts, threaded rod, washer, sleeves, plastic section, expansion sleeves and a cone. All steel component of anchor shall be electro galvanised to minimum 5 micron coating thickness. The plastic section shall be of polyacetal Derlin 100 or equivalent.
e) Chemical bonding anchor shall consist of foil capsule and threaded rod. The foil capsule shall contain the resin and hardener. The threaded rod shall have chiselled tip. The behaviour of anchors under fire shall conform the heating curves as per ISO:834. Anchors of size M8 to M24 shall conform to grade 5.8 and anchors of size M27 to M39 shall conform to grade 8.8 as per IS:1367 part 3. All steel components of the anchors shall be electro-galvanised to minimum 5-micron thickness.

Light Duty Anchors

This anchor shall comprise of stud, nut, washers, expansion sleeve. The one end of the stud shall have thread and the other end shall have cold formed conical head. All steel components of the anchors shall be electro-galvanised to minimum 5-micron thickness. The expansion sleeve shall preferably be of stainless steel of SS316. The anchors shall conform to minimum grade 5.8 as per IS:1367 part 3.

2.02.11 Pipe Joints

MS pipes or GI pipes shall be joined by threaded sockets or by welding. Cast iron pipes shall be socket and spigot joined and caulked with hemp and molten head.

2.03.0 FENCING

2.03.01 Chain Link Fencing

The material requirement shall conform to IS: 2721 latest edition. The chain link fencing shall be woven from 3.15mm dia. wire with mesh size of 50mm. The mesh wire shall not vary from specified dia. by more than $\pm$0.05mm. all steel wire shall be hot dipped galvanised wire. The Dia. shall be measured over the galvanised coating. The line wire shall be 4.0mm dia. mild steel. The stirrup wires for securing the line wire to the intermediate post (RCC/structural steel) shall be 2.5 mm diameter mild steel. The tying wire for securing the chain link fencing to the line wire shall be 1.6mm diameter mild

steel. Hair pin chain staples for fastening down the bottom of galvanised chain line fencing to the concrete sill shall be 3.15mm wire. The ends shall be bent outwards for securing anchorage.

Cleat for eye bolts shall be of uniform size and shall consist of mild steel angle of 75 x 50 x 8 mm. The eye bolts strainer shall consist of bolt with welded eye sufficiently threaded and fitted with a nut and washer. Two-way eye bolt strainer shall have suitable ring nuts fitted after the wires have been strained on one side. Stretcher bar shall consist of mild steel flats 25 x 4.75 mm. They shall be secured to the cleats by steel bolts.

The chain link fencing shall be strained between each pair of straining posts and secured to each straining posts by means of a stretcher bar. One of top line wire shall be threaded through appropriate adjacent row of mesh, care being taken that no meshes in the row are bypassed by the line wire except where deviation is necessary at the straining posts. The second top line wire shall be strained in front of the fencing. The fencing shall be attached to the top and bottom line wire by wire ties spaced at 150mm apart and to the other middle line wire by wire ties spaced at 450mm apart.

The bottom of fencing shall be treated as follows:
Continuous concrete sill 125mm wide x 225mm high for full length between posts shall be cast with the top 25mm above GL and 25mm below the chain link fencing. Hair pin staples shall be threaded through the bottom row of mesh at 750mm c/c and set in the sill to a depth of 150mm.

2.03.02 Barbed Wire Fencing

The barbed wire shall be conforming to IS:278 latest editions. The barbed wire shall be galvanised and galvanising shall conform to the requirement laid down for 'light-coated wire' of IS:4826 and it shall be smooth and relatively free of lumps etc. Wire with excessive roughness blisters, salammoniac spots shall be rejected. The barbed wire shall be made from two-line wire and two-point wire of 2.5 mm thickness each. The barbs shall have four point and shall be formed by twisting two point wires, each two turns, tightly around both or one-line wire (Type A - around both line wire, Type B - around one-line wire) making altogether four complete turns. The barbs shall be so finished that four points are set and located or locked as far as possible at right angle to each other. The barbs shall have a length of not less than 13mm and not more than 18mm. The distance between two barbs shall be 75$\pm$12mm.

Straining posts shall be provided at all ends and corners of fences or at changes in direction or acute variation in level and at intervals not exceeding 66 M on straight lengths of fence. Intermediate posts shall be spaced at regular intervals not exceeding 3.0m. Struts shall be fitted to all straining posts behind the chain link fabric in the direction of line of fence. There shall be four

evenly spaced row of line wire in all. The top line wire shall be doubled, making five-line wire in all. The bottom wire shall be closed to the ground. Each line wire shall be strained tightly by means of eyebolts strainers or winders at each straining points. Each line wire shall be secured to each intermediate post by a wire stirrup passed through a hold in the post and secured to the line wire by three complete turns on each sides of the post. The barbed wire shall be fitted with one dropper at the centre of each bay, secured to the wire so that they could not be bunched together. Droppers for barbed wire shall be of mild steel of not less than 25 x 4.75 mm thick with 38 x 4.85 mm half round staples for fastening the barbed wire to them. Bracing for the rows of barbed wire shall be approved by the Engineer.

3.00.00 ACCEPTANCE CRITERIA

a) All items shall be correct shape, size, weight etc. shown on drawings and schedule of items.

b) For installed items, the tolerances shall be as follows

   i) Permissible deviation from, straightness – 1 in 1000.

   ii) Seats, stiffener connections etc. shall be as per approved drawings and shall not interfere with architectural clearances.

c) All castings shall be free from blowholes, cracks, and other blemishes.

d) All MS wire fencing shall be in true vertical plain, and shall not bulge.

4.00.00 IS CODES

IS:278	Specification for Galvanized Steel Barbed wire for fencing.
IS:816	Code of practice for use of Metal Arc welding for general construction in mild steel.
IS:1367	Industrial Fasteners – Threaded steel fasteners - Technical supply condition.
IS:2721	Specification for Galvanized Steel Chain Link fence fabric.
IS:2812	Arc welding of Aluminum and Alloy

5.00.00 RATES AND MEASURMENTS

5.01.0 Rates

Rates shall include supply, fabrication and installation for misc. metals works as required for completion of works like gates, fencing, handrails, ladders, hangers, anchors etc., unless otherwise specified in Schedule of Items.
Rate for fencing shall also include excavation, concreting and supply, erection & fabrication of post (post made of either structural steel or reinforced cement concrete), unless any specific item is excluded.

5.02.0 Measurements

Measurement for MS gates shall be in MT.

Measurement for galvanised MS wire fencing shall be in Sqm.

Measurement for Anchors shall be in nos. for the type as specified in schedule of items.

Measurement of other misc. metals shall be done in MT unless otherwise specified in schedule of items.

VOLUME: II B

SECTION - D

SUB-SECTION – D9

MASONRY AND ALLIED WORKS

SPECIFICATION NO. PE-TS-999-600-C009

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

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MASONRY AND ALLIED WORKS

1.00.00 SCOPE

This section covers furnishing, installation including handling, transporting, batching, mixing, laying scaffolding, centering, shuttering, finishing, curing, protection, maintenance and repair of common building materials till handing over of masonry and allied works for use in structures and locations covered under the scope of this package.

2.00.00 MATERIALS

a) Brick

Bricks for general masonry work shall be of class designation 7.5 of nominal dimensions as per standard specification under IS: 1077, well burnt, of uniform size, shape and colour, free from cracks, flaws or modules of free lime and emit clear ringing sound when struck. Fractured surface shall show uniform texture free from grits, lumps holes etc. Water absorption after 24 hours' immersion shall not exceed 20% by weight for bricks. Dimensional tolerance shall not exceed 8% of the size shown in drawings for bricks. All bricks shall have rectangular faces and sharp straight edges. The bricks shall show no efflorescence after soaking in water and drying in shade.

Each brick shall have the manufacturer's identification marks clearly marked on the frog. Representative samples shall be submitted and approved samples shall be retained by the Engineer for further comparisons and reference. Any brick not found up to the specification shall be removed immediately from site at the Contractor's own cost.

Bricks shall not be dumped at site. They shall be stacked in regular tiers, even as they are unloaded; to minimize breakage and defacement of bricks. Bricks selected for different situation of use in the work shall be stacked separately.

b) Stone

All stones shall be obtained from approved quarries, hard, tough, durable compact grained, uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. The surface of a freshly broken stone shall be bright, clean, and sharp and shall show uniformity of texture, without loose grains and free from any dull, chalky, or earthly appearance. Stone showing mottled colours shall not be used for face work. A stone shall not absorb more than 5 per cent of its weight of water after 24 hours'

immersion. The type of stone shall be as specified on drawings and/or instructed by the Engineer. Samples shall be submitted by the Contractor and approved samples shall be retained by the Engineer for comparison of bulk supply.

c) Cement

Cement used shall be Ordinarily Portland Cement or Portland Slag Cement or Portland Pozzolana Cement conforming to IS Codes and shall be fresh when delivered. In special cases, Rapid Hardening Portland Cement, Low Heat Cement etc. may be permitted or directed to be used by the Engineer. The Contractor shall submit the manufacturer's certificate for each consignment of cement procured to the Engineer. If at any time, the Engineer feels that the cement being used by the Contractor is not up to specification, he may stop the work and send the samples of the cement to a testing laboratory for standard tests and all expenses incurred thus shall be borne by the Contractor. The Contractor shall also have no claim for this type of suspension of work.

The cement shall be stored above the ground level in perfectly dry and watertight sheds. The bags shall be stacked in a manner so as to facilitate removal or first in first out basis. Any material considered defective by the Engineer shall not be used by the Contractor and shall be removed from the site immediately.

d) Coarse Aggregate

Coarse aggregates shall be as per IS: 383 latest editions, consisting of hard, strong and durable pieces of crushed stone and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles etc. and any other material liable to affect the strength, durability or appearance of concrete.

Aggregates other than crushed stone conforming to the provisions of specification may be used if permitted by the Engineer.

Washing of aggregates by approved means shall be carried out, if desired

by the Engineer.

Grading of coarse aggregates shall generally conform to IS: 383 and shall be such as to produce a dense concrete or the specified proportions and strength and of consistence that will work readily into position without segregation.

Aggregates shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass, or any other injurious substances at any stage.
Aggregate of different size shall be kept in separate stacks. If so desired by the Engineer aggregate from different sources shall be stacked separately with proper care to prevent intermixing.

e) Sand

Sand shall be hard, durable, clean, and free from adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, coal, mica, shale or other laminated materials in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of mortar, plaster or concrete or to cause corrosion to any metal in contact with such mortar, plaster or concrete. All sand shall be properly graded and shall be as per relevant IS Code. Sand for concrete shall conform to IS: 383.

f) Water

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discoloration, efflorescence etc.

g) Reinforcement

Reinforcement steel shall be clean and free from loose mill scales, dust, loose rust, oil and grease or other coatings, which may impair proper bond. Structural steel shall conform to IS: 2062. Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement shall conform to IS: 432. Cold twisted steel bars shall conform to IS: 1786. Hand drawn steel wire fabric shall conform to IS: 1566. Hexagonal wire netting shall conform to IS: 3150. All steel bars including and above 10 mm diameter shall be of tested quality. All wire netting shall be galvanized.

Reinforcement bars shall be stored off the ground and under cover if so desired by the Engineer. If necessary, a coat of cement wash shall be given to the bars to guard against rusting.

3.00.00 INSTALLATION

3:01.00 Soling

3.01.01 Brick Soling

The ground shall be dressed, consolidated by ramming, or by light rolling and a 12 mm thick cushion of sand laid. On the sand cushion the bricks shall be laid with fine joints and placed firmly in position by hammering with wooden mallet. The surface shall be free from undulations. The 'frog' side shall be on the underside. The joints shall be broken the in all direction and bricks cut as required. The pattern of laying and number of layers shall be as per Schedule of item. Orientation shall be as desired by the Engineer. After laying of each layer of bricks sand shall be spread over and worked into the joints to pack the bricks tight.

3.01.02 Stone Soling

The stones for soling shall be selected on the basis of thickness of soling specified in the Schedule of Items. The larger stones shall be laid and the gaps filled by smaller stones. The interstices shall then be firmly packed with sand by flooding with water.

3.02.00 Brick-on-Edge

Excavation shall be done close to the brick dimensions and in perfect alignment. Bricks shall be firmly placed by hammering with wooden mallets and sides and joints packed firmly with earth so that the edging is not disturbed easily. Alignment and level shall be acceptable to the Engineer.

3.03.00 Masonry

3.03.01 General

All masonry work shall be true to lines and levels as shown on drawings. All masonry shall be tightly built against structural members and bonded with dowels, inserts etc. as shown on drawings.

3.03.02 Cement Mortar

Cement mortar shall be prepared with materials specified in clause 2.00.00. Sand for masonry mortar shall conform to IS: 2116. Cement and sand in the specified proportion shall be mixed dry thoroughly and minimum water added to attain required workability.

Surplus mortar droppings from masonry, if received on surface free from dirt may be mixed with fresh mortar if permitted by the Engineer who may direct addition of additional cement without any extra payment. No mortar, which has stood for more than half an hour, shall be used.

3.03.03 Brick Masonry

Bricks shall be soaked by submergence in clean water for at least two hours in approved vats before use. Bricks shall be laid in English bond unless specified otherwise. Broken bricks shall not be used. Cut bricks shall be used if necessary to complete bond or as closers. Bricks shall be laid with frogs upwards over full mortar beds. Bricks shall be pressed into mortar and tapped into final position so as to embed fully in mortar. Inside faces shall be buttered with mortar before the next bricks is placed and pressed against it. Thus all joints between bricks shall be fully filled with mortar.

Mortar joints shall be kept uniformly 10 mm thick. All joints on face shall be raked to minimum 10 mm depth using raking tool while the mortar is still green to provide bond for plaster or pointing.

Where plaster or pointing is not provided, the joints shall be struck flush and finished immediately. Brickworks two bricks thick or more shall have both faces in true plane. Brickwork of lesser thickness shall have one selected face in true plane.

3.03.04 Exposed Brickwork

Brickwork in superstructures, which is not covered by plaster, shall be as shown on drawing and executed by especially skilled mason. Courses shall be truly horizontal and vertical joints truly vertical. Wooden straight edges with brick course graduations and position of window sills and lintels shall be used to control uniformity of brick courses. Masons must check workmanship frequently with plumb, spirit level, rule, and string. All brickwork shall be cleaned at the end of days' work. If face bricks are specified, the brickwork shall be in composite bricks, with face bricks on the exposed face and balance in routine bricks, but maintaining the bond fully. Where face bricks are not specified, bricks for the exposed face shall be specially selected from routine bricks. All exposed brickwork on completion of work shall be rubbed down, washed clean, and pointed as specified. Where face bricks are used carborundum stone shall be used for rubbing down.

3.03.05 Reinforced Brickworks

Reinforcements shall be as specified. All reinforcements shall be thoroughly cleaned and fully embedded in mortar. Where M.S. bars are used as reinforcement, these shall be lapped with dowels if left in R.C. columns or welded to steel stanchions.

3.03.06 Stone Masonry

Stones shall be thoroughly soaked before laying. Stones shall be laid on their natural quarry beds. Individual stones shall be fitted with mallet and properly wedged to reduce thickness of mortar joints. Thickness of joint shall be not less than 8 mm and not greater than 25 mm. At least two stones shall run the full width of the wall for every square meter of surface area.

3.03.07 Exposed Stone work

Stonework, which is to be kept exposed, shall be as shown on approved drawing. It shall be executed by especially skilled mason. Stones used for exposed face shall be specially selected. All exposed stone faces shall be kept clean and free from mortar and pointed up neatly as the work proceeds in a manner called for in the drawings or instructions. A sample wall, 10 Sq.M. area shall be built and approved by the Engineer and all works shall match with this sample.

3.03.08 Composite Masonry

Where stonework facing with brick masonry backing is specified the bond between them shall be achieved by bond stones of dimensions and frequency as desired by the Engineer.

3.03.09 Expansion & Separation Joints

Location of joints shall strictly be as shown on drawings or as instructed by the Engineer. Expansion joints shall be as shown on drawings and specified. Expansion joint filler boards and sealing strips shall have minimum transverse joints. Transverse joints shall meet the approval of the Engineer.

Separation joints shall be with standard waterproof paper or with alkathene sheets about 1 mm in thickness. Length and sealing of laps shall be to the satisfaction of the Engineer.

3.03.10 Mouldings, Cornices, Drip Course

These shall be made as shown in drawings. Bricks or stone shall be cut and dressed as required. If no subsequent finish is envisaged, these shall be rubbed to correct profile with Carborundum stone.

3.03.11 Curing

Masonry shall be cured by keeping it wet for seven days from the date of laying. In dry weather at the end of days' work top surface of masonry shall be kept wet by ponding.

3.03.12 Embedding of fixtures

All fixtures shall generally be embedded in mortar and masonry units shall be cut as required.

3.03.13 Encasing of Structural Steel

This shall be done by building masonry work round flanges, webs etc., and filling the gap between steel and masonry by minimum 12 mm thick mortar. Encased members shall be wrapped with chicken wire mesh when shown on drawings or instructed by the Engineer. The minimum lap in chicken wire mesh shall be 50 mm.

3.04.00 Damp Proof Course (DPC)

Unless otherwise specified Damp-proof course shall be 40 mm thick 'artificial stone' in proportion 1:1½:3 cement sand stone-chips (10 mm down) with admixture of a waterproofing compound as approved by the Engineer. The percentage of admixture shall be as per manufacturer's specifications but not less than 2% by weight of cement. The top surface shall be double Chequered and cured by ponding for seven days.

3.05.00 Damp Proof Membrane

Damp proof treatment using fibre or hessian base bitumen felt shall be 6, 8 or 10 course treatment as specified in IS: 1609. The number of courses shall be as shown as drawings or as specified. Sequence of work shall be as directed by the Engineer. Extreme care shall be taken to prevent damage to felt during and after laying. The Contractor shall be obliged, at his own expense, to rectify any leakage appearing within 5 years of installation by removing and renewing the coats at the point of leakage.

Where shown on drawing, damp proof membrane with one-layer bitumen paper or one layer alkathene sheet shall be laid with minimum 150 mm lap under slabs on grade.

3.06.00 Plinth Protection

Plinth of buildings shall be protected with brick-on-edge paving of minimum 750mm width unless otherwise shown on the drawings. The treatment shall consist of laying bricks in cement mortar 1:6 (1 cement: 6 sand) over a 75mm thick bed of dry graded brick aggregate, 40mm nominal size, grouted with sand. The top shall be finished with 1:2 cement mortar pointing (1 cement: 2 sand). Plinth protection shall be laid with a minimum outward slope of 1 in 50. The brick aggregate shall be well graded, broken from well burnt or slightly over burnt and dense brickbats. It shall be homogeneous in texture, roughly cubical in shape, clean and free from dirt or any other foreign matter.

The ground shall first be prepared to the required slope around the building. The high portions of the ground should be cut down; hollows and depressions filled up to the required level from the excavated earth and rammed so as to give uniform outward slope. The bed shall be watered and rammed with heavy iron square rammers. Surplus earth, if any, shall be disposed off beyond a lead of 50m or as directed by the Engineer.

Over this, 75mm thick bed of aggregate of 40mm nominal size, shall be laid with a minimum outward slope of 1 in 50. Aggregates shall be carefully laid and packed, bigger sized being placed at the bottom. The brick aggregates shall be consolidated dry with heavy iron rammers.

The aggregates shall then be grouted evenly with sand at the rate of 0.6 cubic metre per square metre area, adequately watered to ensure filling of voids by sand and again rammed with heavy iron rammers. The finished surface shall give uniform appearance. After the subgrade has been compacted thoroughly, brick flooring with bricks of specified strength in cement mortar 1:6 (1 cement: 6 sand) shall be laid.

The bricks shall be laid on edge in Diagonal/Herring Bone Bond or other pattern as specified or as directed by the Engineer. Bricks shall be laid on 12mm thick mortar bed and each brick shall be properly bedded and set home by gentle tapping with handle of trowel or wooden mallet. Its inside face shall be buttered with mortar before the next brick is laid and pressed against it. On completion of the portion of flooring, the vertical joints shall be fully filled from the top with mortar. The surface shall present a true plain surface with the required slope.

The pointing shall be done in cement mortar 1:2 (1 cement: 2 sand). The mortar shall be pressed into the joints and shall be finished off flush and level with the edges of the bricks so as give a smooth appearance. The edges shall be neatly trimmed with a trowel and a straight edge. The mortar shall not spread over surface of the masonry.

Brick flooring & pointing shall be kept wet for a minimum period of seven days. These shall be protected from rain by suitable covering when the mortar is green.

4.00.00 I.S. CODES

Some of the important relevant codes for this section are:

IS: 1127: Recommendations for dimensions and workmanship of natural building stones for masonry work.

IS: 1597: Code of Practice for Construction of stone Masonry.

IS: 1609: Code of Practice for laying Damp proof treatment using bitumen felts.

IS: 2212: Code of Practice for Brickwork.

IS: 2250: Code of Practice for preparation and use of masonry Mortar.

IS: 5134: Bitumen Impregnated Paper & Board.

5.00.00 RATES AND MEASUREMENTS

5.01.00 Rates

Unit rate for masonry work shall include the following:

a) Raking out joints for plastering or pointing or finishing the joint flush as the work proceeds.

b) Preparing top sand sides of existing wall for joining old with new work.

c) Providing, dismantling and removing the scaffolding.

Unit rate for DPC shall be inclusive of formwork and bitumen painting.

5.02.00 Measurement

Brickwork in wall of half brick thickness shall be measured separately in Sqm stating the wall thickness and more than half brick thickness shall be measured by volume. Plaster thickness shall not be considered for computation of volume.

Masonry work in sub structure and super structure shall be measured separately, unless otherwise specified in the Schedule of items.

No deductions shall be made and no extra payment shall be made for following:

a) Opening upto 0.1 Sqm each in area. In calculating the area of the opening lintels or sills shall be included along with the size of the opening.

b) Drainage holes and recesses for cement blocks to embed holdfasts for doors, windows etc.

c) Pipe and fixtures upto 300mm dia. and nothing extra shall be paid for the mortar used for fixing.

d) Ends of dissimilar materials (i.e. joists, beams, lintels, posts, girders, rafters, purlins, trusses, corbels, steps, etc.); up to 0.1 sqm in section;

e) Chases of section not exceeding 50 cm in girth;

f) Iron fixtures, such as wall ties and hold fasts for doors and windows;

g) Cement concrete blocks as fcr hold fasts and holding down bolts;

h) Wall plates, bed plaros, and bearing of slabs, CHAJJAS and the like, where thickness does not exceed 10 cm and bearing does not extend over the full thickness of wall;

Reinforcement in masonry work shall be paid separately under respective items.

Damp proof course shall be measured in Sqm. No deduction shall be made and no extra shall be paid for opening upto 0.1 Sqm in area.

Plinth protection shall be measured under respective item of works executed required for completion of the work as specified.

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SECTION - D

SUB-SECTION – D10

FINISH TO MASONRY AND CONCRETE

SPECIFICATION NO. PE-TS-999-600-C010

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

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FINISH TO MASONRY AND CONCRETE

1.00.00 SCOPE

This Section covers finishing, installation, repairing, finishing, curing, testing, protection, maintenance till handing over of finishing items for masonry and concrete. This shall also include the work to be done to make the surface suitable for receiving the finishing treatment.

Before commencing finishing items, the Contractor shall obtain the approval of the Engineer regarding the scheduling of work to minimize damage by other trades. He shall also undertake normal precaution to prevent damage or disfiguration to work of other trades or other installation.

2.00.01 INSTALLATION

2.01.00 Preparation of Surface

All joints in masonry walls shall be raked out to a depth of at least 10 mm with a hooked tool made for the purpose while the mortar is still green. Walls shall be rushed down with stiff wire brush to remove all loose dust from joints and thoroughly, washed with water. All laitance shall be removed from concrete to be plastered.

For all types of flooring, skirting and dado work, the base cement concrete slab or masonry surface shall be roughened by chipping and cleaned of all dirt, grease or loose particles by hard brush and water. The surface shall be thoroughly moist to prevent absorption of water from the base course. Any excess of water shall be mopped up.

At any point, the level of base shall be lower than the theoretical finished floor level by the thickness of floor finish. Any chipping or filling to be done to bring the base in the required level shall be brought to the notice of the Engineer and his approval shall be taken regarding the method and extent of rectification work required.

Prior to commencement of actual finishing work, the approval of the Engineer shall be taken as to the acceptability of the base.

2.02.00 PLASTERING

2.02.01 Mortar

Mortar for plastering shall be as specified.
For sand cement plaster, sand and cement in the specified proportion shall be

mixed dry, on a watertight platform and minimum water added to achieve working consistency. The sand for plaster shall conform to IS: 1542.

No plaster, which has stood for more than half an hour, shall be used; plaster that shows tendency to become dry before this time shall have water added to it.

2.02.02 Application of Plaster

Plaster, when more than 12 mm thick, shall be applied in two coats a base coat followed by the finishing coat. Thickness of the base coat shall be sufficient to fill up all unevenness in the surface; no single coat, however, shall exceed 12 mm in thickness. The lower coat shall be thicker than the upper coat; the overall thickness of the coats shall not be less than the minimum thickness shown on the drawings. The undercoat shall be allowed to dry and shrink before applying the second coat of plaster. The undercoat shall be scratched or roughened before it is fully hardened to form a mechanical key. The method of application shall be 'thrown on' rather than 'applied by trowel'.

To ensure even thickness and true surface, patches of plaster about 100 mm to 150 mm square or wooden screed 75 mm wide and of the thickness of the plaster, shall be fixed vertically about 2000 mm to 3000 mm apart, to act as gauges. The finished wall surface shall be true to plumb, and the Contractor shall, without any extra cost to the Owner, make up any irregularity in the brickwork with plaster.

All vertical edges of brick pillars, doorjambs etc. shall be chamfered or rounded off as directed by the Engineer. All drips, grooves, mouldings and cornices as shown on drawing or instructed by the Engineer shall be done with special care to maintain true lines, levels and profiles. After the plastering work is completed, all debris shall be removed and the area left clean. Any plastering that is damaged shall be repaired and left in good condition at the completion of the job.

2.02.03 Finish

Generally, the standard finish shall be used unless otherwise Shown on drawing or directed by the engineer. Wherever any special treatment to the plastered surface is indicated, the work shall be done exactly as shown on the drawings, to the entire satisfaction of the engineer regarding the texture, color and finish.

a) Standard Finish

Wherever punning is indicated, the interior plaster shall be finished rough; otherwise the interior plaster shall generally be finished to a smooth surface. The exterior surface shall generally be finished with a wooden float.

b) Neat Cement Finish

Immediately after achieving a true plastered surface with the help of a wooden straight edge, the entire area shall be uniformly treated with a paste of neat cement at the rate of one (1) kg. per Sq.M. and rubbed smooth with a trowel.

c) Coloured Plaster Finish

This shall be done in the same way as specified in Clause 2.02.02 but using Coloured cement in place of ordinary cement. When coloured plastering is specified in more than one coat, the topcoat only shall be made with coloured cement.

Coloured cement shall be either ready mixed material or may be obtained by mixing pigments and cement at site, as approved by the Engineer. The pigments to be mixed with cement shall conform to Appendix-A of IS: 2114 latest editions.

Samples of colouring material shall be submitted to the engineer for approval and material procured, shall conform in all respects to the approved samples, which shall remain with the Engineer. All coloured cement and/or pigments shall be stored in an approved manner in order to prevent deteriorations.

d) Pebble-dash Finish

Mortar of required thickness consisting of 1-part cement and 4 parts sand by volume shall be applied in the usual manner as described under plastering Clause 2.02.02. While the mortar is still plastic small pebbles or crushed stone of size generally from 10mm to 20mm as approved by the

Engineer shall be thrown on the plastered surface. The aggregate shall be lightly tapped into the mortar with a wood float or the flat end of oil a trowel, in order to ensure satisfactory bond between the dashing and the mortar.

e) Rough-cast Finish

A wet plastic mix of 3 parts coloured cement 6 parts sand and 4 parts aggregate by volume (gravel or crushed stone of size from 6 mm to 12 as approved by the Engineer) shall be thrown on to the wall by means of a plaster's trowel and left in the rough condition.

f) Scraped Finish

Ordinary plaster as described under Clause 2.02.02 after being leveled and allowed to stiffen for a few hours, shall be scraped with a steel straight edge to remove the surface skin. The pattern shall be as approved by the Engineer.

g) Textured Finish

Mortar consisting of 1-part cement and 3 parts sand by volume shall be applied in a manner as specified under "Plastering" Clause 2.2.2 Ornamental treatments in the form of horizontal or vertical rib texture fan texture etc. shall be applied by means of suitable tools to the freshly applied plastered surface, as approved by the Engineer.

h) Sand Faced Plaster

The plaster shall be applied in 2 coats. The first coat or the scratch coat should be approximately 14mm and shall be continuously carried out without break to the full length of wall or natural breaking points such as doors, windows, etc. The scratch coat shall be dashed on the prepared surface with heavy pressure, brought to true and even surface and then lightly roughened by cross scratch lines, to provide bond for the finishing coat. The mortar proportion for this scratch coat shall be as specified in the respective item or work. The scratch coat shall be cured for at least 7 days & then allowed to dry. The second coat shall be 6mm thick and it shall not be applied until at least 10 days have elapsed after the application of scratch coat. Before application of the second coat, the scratch coat shall be evenly damped. This coat shall be applied from top to bottom in one operation & without joints; finish shall be straight, true, & even. The mortar of this coat shall be as specified under the respective item of work. White sand for finish shall be used for the second coat & for finishing work. Sand for finish shall be of even coarse size & shall be dashed on the surface & sponged.

2.02.04 Curing

All plastered surfaces after laying shall be watered, for a minimum period of seven days, by an approved method, and shall be protected from excessive heat and sunlight by suitable approved means. Moistening shall commence, as soon as the plaster has hardened sufficiently and not susceptible to damage. Each individual coat of plaster shall be kept damp continuously, for at least two days, and then dried thoroughly, before applying the next coat.

2.03.00 Pointing to masonry

All Joints of brickwork shall be raked out to a depth of 10 mm with a hooked tool made for the purpose while the mortar is still green. The brickwork shall then be brushed down with a stiff wire brush, so as to remove all loose dust from the joints and thoroughly washed with water. Mortar consisting of 1-part cement and 3 parts clean, sharp, well graded sand by volume shall be pressed carefully into the joints and finishes with suitably tools to shape as shown on the drawings. Any surplus mortar shall be scalped off the wall face leaving the surface clean.

The pointed surface shall be kept wet for at least three days for curing.

2.04.00 Plaster with Metal Lath

The supports, hangers, brackets, cleats etc. shall be as shown on drawings and/or as approved by the Engineer. These shall have a coat of prime paint before and another coat of approved paint after erection.

The metal lath shall be expanded metal, with 12 mm x 38 mm mesh, 16 thick and 3 mm wide strands. Side laps shall be minimum 12 mm and end laps 25 mm minimum. The plastering shall be minimum 20 mm thick measured from the back of lath and applied in two-layers. The mortar for plastering shall consist of 1-part cement and 4 parts sand by volume mixed as specified in plastering, Clause 2.02.01. The application, finish etc. shall be as specified under relevant clause above. Where called for a 2 mm Plaster of Paris punting shall be applied over plaster as a finishing coat to give perfectly smooth and even finish.

2.05.00 Lime Punning

For plastered surfaces, where an even smooth surface is specified, lime punning with 5 parts of shell lime properly slaked, strained and aged, mixed with 1 part clean, washed, sieved, fine sand by volume shall be done. The thickness of lime punning shall be not less than 2 mm and more than 3 mm. The plastered surface shall be saturated with water before application of the

lime punning. The punting shall be applied by skilled workman and given a smooth and ever finish free from undulations, cracks etc. and to the satisfaction of the Engineer.

2.06.00 Plaster of Paris Punning

Plastered surfaces, where specified shall be finished with Plaster-of-Paris punning. The material shall be from approved manufacturers and approved by the Engineer. The thickness of the punning shall be 2 mm and shall be applied by skilled workmen. The finish shall be smooth, even and free from undulation, cracks etc.

Before bulk work is taken in hand, a sample of punning shall be done on roughly 10 Sq.M. areas and approval of the Engineer taken. The work shall then be taken in hand as per approved sample.

2.07.00 Stone Facing

Stone facing where specified shall be done as shown on design drawings and approved shop drawings. The stone shall be as specified on drawings. Samples of stone shall be submitted to the Engineer for approval and then bulk purchase made. The Contractor shall submit three copies of shop drawings for the Engineer's approval before commencing the work.

The thickness of facing stone shall be not less than 25 mm unless otherwise specified on drawings.

The stone slabs shall be cut and finished to sizes as per pattern shown on drawings. They shall be fastened to wall with suitable non-corrodible anchorage as approved by the Engineer. Where mild steel clamps, stays etc. are used for anchorage, they shall be galvanized (weight of zinc coating shall. not be less than 700 gms per square meter of surface) to prevent rust stains developing on the finished surface. There shall be at least 12 mm gap between the stone and masonry, which shall be filled up and packed by a mortar of 1-part cement and 3 parts of sand by volume. After the mortar is set and cured for at least four days, the exposed surface shall be rubbed and polished as approved by the Engineer.

The completed surface shall be neat, or uniform texture and acceptable to the Engineer.

Where pointing is specified on drawings it shall be done by mortar as specified on drawings.

3.00.00 ACCEPTANCE CRITERIA

Finish to masonry and concrete shall fully comply with the Specifications, approved samples and instructions of the Engineer with respect to lines, levels, thickness, colour, texture, pattern and any other special criteria as mentioned in the body of the specification or as shown on drawings.

4.00.00 I.S. CODE

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

IS: 1661: Code practice for cement and cement-lime plaster finish on wall & ceilings.

IS: 4101: code of practice for external facings and veneers.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall also include providing, dismantling and removing of scaffolding, surface preparation, curing and all type of surface, shapes/ profiles and at all elevations.

5.02.00 Measurement

All plastering shall be measured net (on surface area on which it is applied) in Sqm. Plaster work shall be classified according to the type used and shall be measured separately. Plaster on ceiling and walls shall be measured separately. Soffits of stairs shall be measured as plastering on ceiling.

No deduction shall be made for opening not exceeding 0.5 Sqm and for ends of beams, joints, etc. also no payment shall be made for reveals, jams, soffits, sills of these openings.

50% deduction shall be made for opening exceeding 0.5 Sqm but not exceeding 3.0 Sqm each and no addition shall be made for reveals, jams, soffits, sills etc.

In case of opening exceeding 3.0 Sqm each, deduction shall be made for opening but jams, soffits, and reveals shall be measured and paid for.

VOLUME: II B

SECTION - D

SUB-SECTION – D11

PAINTING, WHITEWASHING, POLISHING

SPECIFICATION NO. PE-TS-999-600-C011

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
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PAINTING, WHITE WASHING, POLISHING, ETC.

1.00.00 SCOPE

This section covers painting, white washing, varnishing, polishing etc. of both interior and exterior surfaces of wood work, masonry, concrete plastering, plaster of Paris, false ceiling, structural and other miscellaneous steel items, rain water down comer, floor and roof drains, soil, waste and service water pipes, and other ferrous and non-ferrous metal items.

Copper, bronze, chromium plate, Nickel, stainless steel and aluminium shall generally not be painted or finished except if otherwise specified.

Before commencing painting, the Contractor shall obtain the approval of the Engineer in writing regarding the schedule of work to minimize damage; disfiguration or staining to work of other trades or other installations.

2.00.00 INSTALLATION

2.00.01 Materials

Materials shall be highest grade products or well-known approved manufacture and shall be delivered to the site in original sealed containers, bearing brand name, manufacturer's name and colour shade, with labels intact and seals unbroken. All materials shall be subject to inspection, analysis and approved by the Engineer. It is desired that materials of one manufacturer only shall be used as far as possible and paint of one shade is obtained from the same manufacturing batch. Each and every supply of primer, finish paint etc. shall be accompanied by manufacturer’s test certificate. All paint shall be subject to analysis from random samples taken at site from painter’s bucket, if so desired by the Engineer.

All prime coats shall be compatible to the material of the surface to be finished as well as to the finished coats to be applied.

All unspecified materials such as shellac, turpentine or linseed oil shall be of the highest quality available and shall conform to the latest IS standards. All such materials shall be made by reputable recognized manufacturers and shall be approved by the Engineer.

All colours shall be as per painting schedule and tinting and matching shall be done to the satisfaction of the Engineer. In such cases, where samples are required, they shall be executed in advance with the specified materials for the approval of the Engineer.

a) White Wash/Colour Wash

Shall be done from pure shell lime or fat lime, or a mixture of both as instructed by the engineer, and shall conform to IS: 712 latest editions. Samples of lime shall be submitted to the Engineer for approval, and lime as per approved sample shall be brought to site in unslaked condition. After slaking, it shall be allowed to remain in a tank for two days and then stirred up with a pole, until it attains the consistency of thin cream. 100 grams of gum to 6 litres of white wash water and a little of indigo or synthetic ultramarine blue shall be added to the lime. Mineral colour not affected by lime shall be added to white wash to get the required tint/shade approved by the Engineer.

b) Dry distemper

Shall be made from suitable pigments, extenders, lime proof tinters, water-soluble binders etc. and share conform to IS: 427. The distemper shall be diluted with prescribed thinner in a manner recommended by the manufacture. Only sufficient quantity of distemper required for a day's work shall be prepared.

c) Oil Bound Washable Distemper

Shall be of oil emulsion type containing suitable preservatives and shall conform to IS: 428. The distemper shall be diluted with prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for a day's work shall be prepared.

d) Waterproof Cement Paint

Shall be made from best quality white cement and lime resistant colours with accelerators, waterproofing agents and fungicides. The paint shall conform to IS: 5410.

e) Acrylic Emulsion Paint

Shall be water-based acrylic copolymer emulsion with rutile titanium dioxide and other selected pigments and fungicide conforming to IS: 5411 (Part-1). It shall exhibit excellent adhesion to plaster and cement surface and shall resist deterioration by alkali salts. The paint film shall allow the moisture in wall to escape without peeling or blistering. The paint, after it is dried, shall be able to withstand washing with mild soap and water without any deterioration in colour, or without showing flaking, blistering, or peeling.

f) Synthetic Enamel Paint

Shall be made from synthetic resins and drying oil with rutile titanium dioxide and other selected pigments to give a smooth, hard, durable and glossy finish to all exterior and resist interior surfaces. White and pastel shades shall not be yellowing and darkening with aging. The paint shall conform to IS: 2932 and IS: 2933.

g) Aluminium Paint

Shall be in two pack containers and shall resist weathering. The paint shall conform to IS: 2339.

h) Varnishing

Shall be best quality alkyd varnish suitable for brushing over the tint of paint or light natural wood and shall not darken or yellow with age.

i) French Polish

Shall be made from best quality shellac, denatured spirit and other suitable alcohol soluble ingredients and made by a well-known approved manufacturer. The material shall conform to IS: 348.

French polish shall not be used on bare wood it shall only be used as finishing coat on wood after the woods pre-treated with a liquid wood filler conforming to IS: 345 is applied and rubbed out.

j) Bitumen paint (black bituminous anti-corrosive paint)

Bitumen based anti-corrosive paint conforming to IS: 158 shall be used.

2.00.02 Storage

The Contractor shall arrange for safe and proper storage of all materials and tools. The storage space if allotted within the building shall be adequately protected from damage, disfigurement, & stains. Paint shall be kept covered at all times and mixing shall be done in suitable containers. All necessary precautions shall be taken by the contractor to prevent fire.

2.01.00 Preparation of surface

Before starting the work, the Contractor shall obtain the approval of the Engineer regarding the soundness & readiness of the surface to be painted on.

2.01.02 Wood

All surfaces shall be free from, dirt and loose or peeling paints. The surface shall be rubbed down smooth. All nails & screws shall be sunk below the surface and filled with putty after applying an under coat. Small knots that do not justify cutting and sap streaks shall be covered with minimum 2 coats of pure shellace coating applied thinly & extended 25 mm beyond the area. All large, loose, or resinous knots shall be removed and filled with sound wood. All work shall be done as per IS: 2338.

2.01.02 Masonry, Concrete, and Plastered Surface

Surface shall be free from all oil, grease, efflorescence, mildew, loose paint, or other foreign and loose materials. Masonry cracks shall be cleaned out and patch filled with mortar similar to the original surface and uniformly textured. Where this type of resurfacing may lead to the finishing paint being different in shade from, the original surfaces, the resurfaces area shall be treated with minimum one coat of cement primer, which should be continued to the surrounding area for a distance of minimum 100 mm.

Surface with **Mildew or Efflorescence** shall be treated as below:

All mildewed surfaces shall be treated with an approved fungicide such as ammoniacal wash consisting of 7g of copper carbonate dissolved in 80ml liquor ammonia and diluted to water, or 2.5 percent magnesium silicofluoride solution and allowed to dry thoroughly before paint is applied.

2.01.03 Metal

The surface preparation shall be done in accordance with IS:1477 (Part-1) ‘Code of practice for painting of ferrous metals in building’ and as directed by Engineer. All metal surfaces shall be absolutely clean, dry, and free from rust, scales, weld slag, flux deposit, wax, grease, dried soap films, foreign matters like cement mortar etc. and free from existing loose red oxide zinc chromate primer and should be removed by means of wire brushes, hand scrappers, sand paper, emery cloth, emery papers, or by mechanical power tools etc. or as directed by Engineer. For exposed chemical resistant paints, surfaces shall be blast cleaned to near white metal. All galvanized iron surfaces shall be pre-treated with a compatible primer according to the manufacturer's direction. Any abrasion in shop coat shall be touched up with the same quality of paint as the original coat. The actual painting work should be commenced only after obtaining clearance from the Engineer regarding proper cleaning of the surface.

2.02.00 Application

2.02.01 General

The method of application shall be as recommended by the manufacturer. In case of selection of special shades and colour (not available in standard shades) the Contractor shall mix different shades and prepare test panels of minimum size 1 meter square as per instruction of the Engineer and obtain his approval prior of application of finishing paints.

Proper tools and implements shall be used. Scaffoldings used shall be independent of the surface to be painted to avoid shade differences of the freshly repaired anchor notes.

Painting shall be done by skilled labours in a workmanlike manner. All materials shall be evenly applied so as to free of sags, runs, crawls, or other defects. All coats shall be of proper consistency. In case of application by brush, no brush marks shall be visible. The brushes shall be clean and in good condition before application of paint.

All priming undercoat for painting shall be applied by brush only, and rollers spray equipments etc. shall not be used.

No work shall be done under conditions that are unsuitable production of good results. No painting shall be done when plastering is in progress or is drying. Application of paint, which seals the surfaces to moisture shall only be done after the moisture on and below the surface has dried out.

All coats shall be thoroughly dry before succeeding coat is applied. Coats of painting as specified are intended to cover surfaces perfectly. In case the surface is not covered property by applying the specified number of coats, further coats shall be applied by the Contractor when so desired by the Engineer.

All primers and undercoats shall be tinted to approximate the colour of the finishing coats. Finished coats shall be of exact colour and shade as per approved samples and all finish shall be uniform in colour and texture. All parts of mouldings and ornaments shall be left clean and true to finish.

Painting on ferrous metal surface shall, be done as per IS: 1477 (Part I & 2). The total dry thickness of film should not be less than 120 Micron.

2.02.02 White Washing

The surface where white washing is to be applied shall be cleared of all loose materials and dirt. All holes and irregularities of the surface shall be filled up with lime putty and shall be allowed to dry up before white washing.

One coat of whitewash shall consist of one stroke from top downwards, another from bottom upwards over the first stroke and another from left to right before the previous one dries up. Second coat shall be applied and in case the Engineer feels that one or more coats are required the Contractor shall do so without any extra cost to the Owner. No brush marks shall show on the finished surface.

2.02.03 Dry Distemper

New plastered surface shall be allowed to dry for at least two months. New lime or lime cement plastered surface shall be washed with a solution of 1-part Vinegar to 12 parts water or 1:50 sulphuric acid solution and for 24 hours after which the wall shall be thoroughly washed with clean water. For cement-plastered surface, the surface shall be washed with solution of 100 gms. of zinc sulphate to 1 litre of water and allowed to dry.

Dry distempering shall be done as per manufacturers instruction. In applying the distempers, the brush, should first be applied horizontally and immediately crossed off perpendicularly. Brushing shall not be continued too long, otherwise brush marks may result.

2.02.04 Oil bound washable distemper

The distemper shall be applied after surface is primed with an alkali resistant primer, and followed by minimum two coats of oil bound washable distemper all as per manufacturer's instruction.

2.02.05 Waterproof Cement Paint

Surface to be coated with cement paint shall be washed and brushed down. As soon as the moisture has disappeared, the surface shall be given one coat of paint. Care shall be taken so that the paint does not dry out too rapidly. After 4 to 6 hours, the water shall be sprinkled over the surface to assist curing and prevent cracking. After the first coat has dried (24 to 48 hours) the second coat shall be applied in a similar manner. The finished surface shall be kept moist by occasional sprinkling with water for seven days after painting.

2.02.06 Acrylic Emulsion Paint

Paint shall be applied after providing one coat of cement primer solvent of approved quality and primer shall be conforming to IS: 109. Lime gauged cement plastered surfaces shall not be painted for at least one month after plastering. A sample patch shall be painted to check alkali reaction if so desired by the Engineer. Painting shall be done strictly as per manufacturer's specification.

2.02.07 Synthetic Enamel Paint

Shall be applied on properly primered surface. Sub sequential coat shall not be applied till the previous coat is dry. The previous shall be lightly sand papered for better adhesion of subsequent coats.

2.02.08 Aluminium Paint

The paint, supplied in two pack containers shall be mixed and applied strictly as per manufacturer's direction. When more than one coat of paint is required or indicated, the next coat shall only be applied after the previous coat become hard dry.

2.02.09 Clear Synthetic Varnish

The Varnish shall be applied on wood surface after (a) filling, (b) staining & (c) sealing operations are carried out. The application of a combination of filler and stain shall not be permitted.

For the finishing coats of varnish, the surface shall be allowed to dry and be rubbed down lightly, wiped off and allowed to dry. Careful attention to cleanliness is required for varnishing. All dust and dirt shall be removed from the surface as well as from the neighbourhood. Damp atmosphere and draughts shall be avoided, and exposure to extreme heat or cold & dampness shall not be allowed.

The varnish shall be applied liberally with a brush and spread evenly over a portion of the surface with light strokes to avoid frothing. It shall be allowed to flow on white the next section is being laid on excess varnish shall then be scrapped off the brush and the first section be crossed, recrossed and then laid off lightly. The varnish once it has begun to set shall not be retouched. In case of any mistake in application, the varnish shall be removed and the work started afresh.

The varnish shall be minimum of two coats, with the first coat being a flatting varnish. This shall be allowed to dry hard and be flatted down, before applying the next coat. Sufficient time must be allowed between coats to get a

hard dry surface before next coat is applied. All work shall be as per relevant IS Code.

2.02.10 French polish

All unevenness of the surface shall be rubbed down to smoothness with sand paper and the surface shall well dusted. The pores in the shall be filled up with a paste of whitening in water or methylated spirit with a suitable pigment like burnt siemme or umber.

After application of the filler paste, the French polish shall be applied with a pad of woollen cloth covered by a fine cloth. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles so that the polish is sparingly but uniformly applied over the entire area to give an even surface. A trace of linseed oil may be used on the pad for case of application. The surface shall be allowed to dry before further coats are applied in the same manner. To finish off, the pad shall be covered with a fresh piece of clean fine cloth, slightly damped with methylated spirit, and rubbed lightly and quickly with circular motions to leave the finished surface with a uniform texture and high gloss.

2.02.11 Chemical Resistant Paint

For chemical resistant paints, epoxy, chlorinated rubber, or vinyl butryl paint system shall be used. Manufacturer's recommendation shall be followed regarding the paint system, exposed to moderately to severe corrosive condition and subject to acid/alkali spillage & fumes, shall be followed.

2.03.00 Protection

Furniture and other movable objects, equipment, fittings and accessories shall be moved, protected and replaced upon completion of work. All stationary equipment shall be well covered so that no paint can fall on them. Work finished by other agencies shall be well protected. All protections shall be done as per instructions of the Engineer.

2.04.00 Cleaning up

In addition to provisions in general conditions the Contractor shall, upon completion of painting etc. remove all marks and make good surfaces, where paint has been splashed or splattered, including all equipment, fixtures, glass, furniture, fittings etc. to the satisfaction of the Engineer.

3.00.00 ACCEPTANCE CRITERIA AND TESTING

a) All painted surfaces shall be uniform and pleasing in appearance.

b) All varnished surfaces shall be of uniform texture and high glossy finish.

c) The colour, texture etc. shall match exactly with those of approved samples.

d) All stains, splashes, and splatters of paints and varnishes shall be removed from surrounding surfaces.

Testing

a) As, each part of the work is under progress, i.e. preparation of surface, providing primer, providing different coats of finishing paints, it shall be passed by the Engineer. Variation from the drawings or specification or standard etc. shall not be accepted. The Contractor shall ascertain from the Engineer as to which parts will be inspected and passed from time to time. The Contractor shall provide all necessary arrangement for inspection of the painting work during its different working phase. The Contractor shall provide necessary scaffolding, approach for inspection of the above as per direction and satisfaction of the Engineer. All the necessary cost for scaffolding, approach, platform, lighting arrangement testing and inspection shall be borne by the Contractor. Such inspection and testing will not, however, exonerate the Contractor from his responsibilities for proper workmanship, material etc.

b) The Contractor shall carry out all sampling and necessary testing in accordance with the relevant Indian Standards and shall conduct such tests as called for by the Engineer. Where no specific testing procedure is mentioned in the relevant codes, the tests shall be carried out as per the prevalent accepted Engineering practice as per the direction of the Engineer. Tests shall be done in a laboratory, approved by the Engineer, and cost of testing shall be borne by the contractor.

c) Material/workmanship unsuitable for acceptance shall he removed and replaced by the Contractor. The work shall be redone as per Specification of the contract and direction of the Engineer without extra cost to owner.

4.00.00 I.S. CODE

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

IS: 348	Specification for French polish
IS: 427	Specification for Distemper, dry colour as required.
IS: 428	Specification for Distemper oil emulsion, colour as required.
IS: 1477 (I & II)	Code of Practice for painting of ferrous metal in buildings.

IS: 2338 (I & II)	Code of Practice for finishing of wood and wood based materials.
IS: 2339	Specification for Aluminium, Paints for general purposes in dual containers.
IS: 2395	Code of Practice for painting concrete, masonry, and Plaster surface.
IS: 2932	Specification for enamel, exterior type-1.
IS: 5410	Specification for cement paint, colour as required.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall be unit rates for complete items described in the "Schedule of Items".

Rate shall include cleaning, preparation of surface, supply and application of primer, painting and providing all protection and scaffolding required at site.

5.02.00 Measurements

Painting over the concrete/masonry/wooden surface shall be measured net (on the surface area on which it is applied) in Sqm.

No deduction shall be made for opening not exceeding 0.5 Sqm and ends of beams, joints, etc. also no payment shall be made for reveals, jams, soffits, sill of these openings.

50% deduction shall be made for opening exceeding 0.5 Sqm but not exceeding 3.0 Sqm each and no addition shall be made for reveals, jams, soffits, sills etc.

In case of opening exceeding 3.0 Sqm each, deduction shall be made for opening but jams, soffits, and reveals shall be measured and paid for.

Corrugated surfaces shall be measured flat and measured area shall be increased by 15%.

Painting of structural steel works shall be measured in M.T. of fabricated steel (as per section D-17 clause 6.02.00 i.e. Mode of measurement of technical specification for fabrication of structural steel works) unless specified otherwise.

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SECTION - D

SUB-SECTION – D12

FLOOR FINISH AND ALLIED WORKS

SPECIFICATION NO. PE-TS-999-600-C012

Maharatna Company

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
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FLOOR FINISH AND ALLIED WORKS

1.00.0 SCOPE

This section covers furnishing, installation, finishing, curing, testing, protection, maintenance till handing over various types of floor finishes, and allied items of work as listed below

a) In Situ Finishes

i) Integral finish to concrete base

ii) Terrazzo finish

iii) Granolithic finishes

iv) Patent Stone

v) Metallic Hardener like “Ironte”/Hardonate Finish

vi) Mastic Asphalt finishes

vii) Chemical Resistant finish

b) Tiled Finishes

i) Terrazzo tile

ii) Chequered tile

iii) Glazed tile

iv) Tesse rae (Mosaic etc.)

v) Chemical Resistant

vi) Rubber, Vinyl etc.

vii) Stone Slab including Kota Stone.

1.01.00 Base

The base to receive the finish is covered under other relevant specifications.

1.01.01 Sequence

Commencement, scheduling and sequence of the finishing works shall be planned in detail and must be specifically approved by the Engineer in view the activities of other agencies working in that area. However, the Contractor for the finishing items shall remain fully responsible for all normal precautions and vigilance to prevent any damages whatsoever till handing over.

2.00.00 INSTALLATION

2.00.01 Special Materials

Basic materials are covered elsewhere under the Specification. In general, all such materials shall be as per relevant Codes where available. In all cases these materials shall be of the best quality available indigenously unless specified otherwise.

The materials for finishing items must be procured from well-reputed specialized manufacturers and on the basis of approval of samples by the Engineer. The materials shall be ordered, procured and stored well in advance to avoid compulsion to use substandard items to maintain in the construction schedule.

2.00.02 Workmanship

Only workers specially experienced in particular items of finishing work shall be engaged, where such workers are not readily available, with the Engineer's permission, experienced supervisors recommended by the manufacturer shall be engaged. In particular cases where the Engineer so desires the Contractor shall get the finishing items installed by the manufacturer.

2.00.03 Preparation of the Base Surface

The surface to be treated shall be thoroughly examined by the Contractor. Any rectification necessary shall be brought to the notice of the Engineer and his approval shall be taken regarding method and extent of such rectification work.

For all types of flooring, skirting, dado and similar locations, the base to receive the finish shall be adequately roughened by chipping, raking out joints and cleaning thoroughly all dirts, grease etc. with water and hard brush and

detergent if required, unless otherwise directed by the manufacturer of any special finishing materials or specifically indicated in this specification.

To prevent of water from the finishing treatment the base shall be thoroughly soaked with water and all excess water mopped up.
The surface shall be bone dry where adhesives are used for fixing the finishes.

Prior to commencement of actual finishing work, the approval of the Engineer shall be taken as per the acceptability of the surface.

2.01.00 In Situ Finishes

2.01.01 Integral Finish to Concrete Base

While the surface of the concrete laid as per specification for 'Cement Concrete' has been fully compacted and levelled but the concrete is still `green' thick slurry, made with neat cement shall be applied evenly and worked in with iron floats. When the slurry starts to set it shall be pressed with iron floats to have a firm compact smooth surface without trowel mark or undulations. This finish shall be as thin as possible by using 2.2 kg. of cement per Sq.M. of area.

The surface shall be kept in shade for 24 hours and then cured for at least 7 days continuously by flooding with water. The surface shall not be subjected to any load or abrasion till 21 days after lying.

As desired by the Engineer the surface, while still 'green' shall be indented by pressing strings, the marking shall be of even depth, in straight lines and the panels shall be of uniform and symmetrical patterns.

2.01.02 Terrazzo Finish in Situ

It shall consist of an underbed and a topping laid over an already laid and matured concrete base.

a) Thickness

Unless otherwise specified the total thickness of the 'finish shall be minimum 40 mm for horizontal and 25 mm for vertical surface of which the topping shall be not less than 10 mm. While the topping shall be of uniform thickness the underbed may very in thickness to provide necessary slopes. The vertical surface shall project out 6 mm from the adjacent plaster or other finish. Necessary cutting into the surface receiving the finish shall be done to achieve the specified thickness. All junctions of vertical with horizontal shall be rounded neatly to uniform radius of 25 mm.

b) Mix

i) Underbed

The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 parts cement, 1½ parts sand and 3 parts stone chips by volume. For vertical surfaces the mix shall consist of 1-part cement to 3 parts sand by volume. The sand shall be coarse. The stone chips shall be 10 mm down well graded. Only sufficient water to be added to give a workable consistency.

ii) Topping

The mix for the topping shall be composed of cement, colour Pigment, marble dust and marble chips. Proportions of the ingredients shall be such as to produce the terrazzo of colour texture and pattern approved by the Engineer. The cement shall be white or gray or a mixture of the two to which pigment shall be added to achieve the desired colour. To 3 parts of this mixture 1-part marble powder by volume shall be added and thoroughly mixed dry. To 1 part of this mix 1 to 1½ parts of marble chips by volume shall be added and thoroughly mixed dry again.

The pigment must be stable and nonfading. It must be very finely ground. The marble powder shall be from White marble and shall be finer than IS Sieve No.: 30. The size of marble chips shall be between 1 mm to 20 mm. Sufficient quantity to cover each visible area shall be prepared in one lot to ensure uniform colour. Water to make it just workable shall be added to a quantity that can be used up immediately before it starts to set.

c) Laying

The underbed shall be laid in panels. The panels shall not be more than 5 Sq.M. in area of which no side shall be more than 2.5 M. long. For exposed locations the maximum area of a panel shall be 2.0 Sq.M. The panel shall be laid in alternate bays or chequered board pattern. No panel shall be cast in contact with another already laid until the latter has contracted to the full extent.

Dividing strips made of aluminium or glass shall be used for forming the panels. The strips shall exactly match the total depth of underbed plus topping.

After laying, the underbed shall be levelled compacted and brought to proper grade with a screed or float. The topping shall be laid after about 24 hours while the underbed is still somewhat “green” but firm enough to receive the

topping. A slurry of the mixture of cement and pigment already made shall be spread evenly and brushed in just before laying the topping. The topping shall be rolled for horizontal areas and thrown and pressed for vertical areas to extract all superfluous cement and water and to achieve a compact dense mass fully bonded with the underbed. The surface of the topping shall be trowelled over, pressed and brought to a smooth dense surface showing a minimum 75% area covered by marble chips in an even pattern of distribution.

d) Curing

The surface shall be left for curing for about 12 to 18 hours and then cured by allowing water to stand on the surface or by covering with wet sack for four days.

e) Grinding and Polish

When the surface has sufficiently hardened it shall be watered and ground evenly with rapid cutting coarse grade (no.80) grit blocks, till the marble chips are exposed and the surface is smooth. Then the surface shall be thoroughly washed and cleaned. A grout with already prepared mixture of cement and pigment shall be applied to fill up all pinholes. The surface shall be cured for 7 days by keeping it moist and then ground with fine grit blocks (no.: 120). It shall again be cleaned with water, the slurry applied again to fill up any pinholes that might have appeared and allowed to be cured again for 5 days. Finally, the surface is ground a third time with very fine grit blocks (no.: 320) to get smooth surface without any pinhole. A suitable machine shall do the grinding. Where grinding machine cannot be used hand grinding may be allowed when the first rubbing shall be with carborundum stone of coarse grade (no.:60), second rubbing with medium grade (no.: 80) and final rubbing and polishing with fine grade (no.: 120). The surface shall be cleaned with water, dried, and covered with soil free, clean sawdust if directed by the Engineer. The final polishing shall be postponed till before handing over if desired by the Engineer. Just before handing over the surface shall be dusted with oxalic acid at the rate of 0.33 gm. per. Sq.M., water sprinkled on to it and finished by buffing with felt or hessian bobs. The floor shall be cleaned with soft moist rag and dried. However, all excess wax polish to be wiped off and the surface to be left glossy, but not slippery.

2.01.03 Granolithic Finish

Granolithic finish shall either be laid monolithically over base concrete or separately over hardened base concrete.

a) Thickness

The finish shall be average 20 mm and minimum 12 mm thick, unless specified otherwise.

b) Mix

The mix shall consist of 1-part cement, 1-part coarse sand, 2 parts coarse aggregate by volume. The coarse aggregate shall be very hard like granite and well graded between 6 mm and 12 mm. Minimum quantity of water to get workability shall be added.

c) Laying of Monolithic Topping

The concrete base shall be laid as per specification "Cement Concrete" and levelled upto the required grade. The form shall remain sufficiently protruding to take the finish.

Within about 3 hours of laying the base while it is still fully -green- the topping shall be laid evenly to proper thickness and grade. If considered necessary, the surface 'of the base shall roughened by wire brushing. Unless manual operation is permitted by the Engineer, mechanical vibrators of suitable design shall be used to press the topping firmly and work vigorously and quickly secure full bond with concrete base.

The laitance brought to the surface during compression shall be removed carefully without disturbing the stone chips. The surface shall then the lightly trowelled to remove all, marks. When sufficiently set, hand trowelling shall be done to secure a smooth surface without disturbing the stone chips.

For large areas the laying shall be in panels of maximum 25 Sq.M. area. The panels shall be laid in chequered board pattern.

d) Laying of Topping Separately on Hardened Base

The base concrete shall be prepared as stated in clause 2.00.03 and a slurry of neat cement applied just prior to laying the granolithic concrete mix (1:1:2). The method of compaction etc. shall be same as for monolithic topping.

Curing

Immediately after laying, the finish shall be protected against rapid drying. As soon as the surface had hardened sufficiently, it shall be kept continuously moist for at least 10 days by means of wet gunny bags or pounding of water on the surface. The floor shall not be exposed to heavy traffic during this period.

f) Grinding

If grinding is specified, it shall start only after the finish has fully set. Clause 2.01.02 (e) shall be followed. However, the Engineer shall decide upon the ultimate polish required.

g) Finishing

Where specified, sodium, silicate or magnesium or zinc silico fluoride treatment shall be done. The number of coats to be applied shall be as per approved drawings or as instructed. The concentration and method of application of the solutions shall be as specified in IS: 5491.

2.01.04 Patent Stone

It shall consist of an underbed and a topping laid on an already laid and matured concrete base.

a) Thickness

The patent stone finish shall have thickness as stipulated under clause 2.01.02 (a) except that the topping shall be 12 mm thick.

b) Mix

i) Underbed

The mix shall be as stipulated under clause 2.01.02 (b).

ii) Topping

The mix for the topping shall consist of 1-part cement and 2-part stone aggregate 6mm nominal size by volume.

c) Laying

The Patent Stone finish including the underbed shall be laid in alternate bays or in Chequered board pattern. No panel shall be cast in contact with another already laid till the contraction of the latter has already taken place.

The maximum area of each panel shall be 3 Sq.M. of which no side shall be more than 2 M. long.

A cement grout shall be applied and worked into the surface to receive the finish; the underbed then laid, compacted, and leveled to proper grade with

a screed or float. The topping shall be applied evenly on the underbed while it is not fully set but firm enough and rolled and pressed to get full bond. The topping shall be trowelled to a dense finish to the satisfaction of the Engineer. All trowel marks shall be mopped out with a soft cloth to give a clean smooth surface.

After the surface is sufficiently set, the finished floor shall be kept moist for 7 days for curing. If desired the finish shall be polished as directed by the Engineer.

2.01.05 Metallic Hardener Like 'Ironite'/ `Hardonate' Finish

This will consist of a topping (incorporating iron particles) to bond with concrete base while the latter is `green'.

a) Thickness

Unless otherwise specified the metallic hardener finish shall be of 12 mm depth.

b) Material

The hardening compound shall be uniformly graded iron particles free from non-ferrous metal impurities, oil, grease, sand soluble alkaline compounds or other injurious materials when desired by the engineer, actual samples shall be tested.

c) Mix

Proportion of the metallic hardener shall be as specified or as indicated by the manufacturer. However, in absence of any such direction 1 part metallic hardener shall be mixed dry, with 4 parts cement, by weight. To this mixture 6 mm nominal size stone chips shall be added in proportion of 1-part cement (mixed with hardener) to 2 parts of stone chips by volume and uniformly mixed. Minimum quantity of water shall be added to make it workable.

d) Laying

The concrete floor shall be laid as per specification 'Cement Concrete' and levelled upto required grade. The forms, if any, shall remain sufficiently projecting to make the finish. The surface shall be roughened by wire brash as soon as possible.

The finish shall be laid while the concrete underbed is still very `green' within about 3 hours of laying of the latter. The finish shall be of uniform thickness and even dense surface without trowel marks, pin holes etc. This topping layer shall be pressed firmly and worked vigoursly and quickly to secure full bond with the concrete base. Just when the initial set starts the surface shall be finished smoothened with steel trowel.

The finished floor shall be cured for 7 days by keeping it wet.

2.01.06 Mastic Asphalt Finish

This is a one-layer treatment on concrete or brick base.

a) Thickness

The thickness shall be as specified in the drawing.

b) Materials

Bitumen shall be industrial Bitumen of the grade 90/15 and 75/15 conforming to IS: 702.

Mineral filler shall be dry stone dust passing through 75 micron IS Sieve.

Fine aggregate shall be crushed and graded natural limestone or other hard work.

Coarse aggregate shall be crushed siliceous stone or other approved aggregate 6 mm stone chips shall be used for finish upto 20 mm thick & 10 mm chips for thicker finish.

c) Composition

Bitumen mastic shall conform IS: 1195 and shall be either brought to site in blocks weighing about 25 Kg or prepared at site. If brought in blocks, these shall be remelted in mechanically agitated mastic cookers and coarse aggregate, preferably preheated fed in successive portions until the complete change is thoroughly, incorporated. At no stage during the remelting and mixing process, shall the temperature exceed 205°C.

d) Laying

The hot mastic shall be laid on dry base surface cleaned thoroughly by wire brushing and sweeping. The mastic shall be levelled and when cooled to some extent shall be finished with a wooden float with addition of small

quantity of fine sand if required. No load shall be allowed till the finish has cooled to normal temperature.

The mastic shall be laid in suitable panels of about 1.5 Sq.M. in area each formed by formers. Succeeding panels shall be laid overlapping the finish panel so as to melt its edges and form a continuous finish without joint.

2.01.07 Chemical Resistant in Situ Finish

Chemical resistant in situ finish shall be as epoxy resin with suitable filler material over a primer. The minimum thickness shall be 6 mm. About its performance the Engineer shall have to be fully satisfied by test results and examination of similar treatment already in existence. The contractor shall get it done by a specialized Manufacturer and get guarantee of performance from the organization and pass it on to the Owner in addition to his own guarantee.

2.02.00 Tiled Finish

These shall include finish tiles, stone slabs, and similar manufactured or natural items over already laid and matured base of concrete or masonry by means of an underbed or an adhesive layer.

2.02.01 Terrazzo Tile Finish

The finish will consist of manufacture terrazzo and an underbed.

a) Thickness

The total thickness including the underbed shall be minimum 40 mm for floors 30 mm for walls unless otherwise specified.

The skirting, dado and similar vertical surfaces shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the tiled finish, to accommodate the specified thickness shall be done.

b) Tiles: Terrazzo

The tiles shall, unless specifically permitted in special cases be machine made under quality control in a shop. The tile shall be pressed hydraulically to a minimum of 140 Kg. per Sq.cm.

Each tile shall bear on its back permanent and legible trademark of the manufacturer. All angles of the tiles shall be right angles all arises sharp and true, colour and texture of the wearing face uniform throughout. Maximum tolerance allowance length and breadth shall be ± 1 mm and the

thickness ± 3 mm. Face of the tile shall be plane, free from pinholes and other blemishes.

The tiles shall be composed of a backing and topping. The topping shall be of uniform thickness not less than 10 mm.

The total thickness including the topping shall be as specified but not less than 20 mm in any case.

The backing shall be composed of 1 part ordinary gray cement and 3 parts of stone chips by weight mixed with water.

The topping shall be as specified under clause 2.01.02 (b).

The tile shall be cured at the shop for at last 14 days before delivery to the site. First grinding shall be given to the tiles at the shop before delivery. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be carefully stored to prevent staining by damp, rust, oil, and grease or other chemicals.

Tiles made in each batch shall be kept and used separately so that colour of each area of the floor may remain uniform.

The manufacturer shall supply along with the tiles the grout mix containing cement and pigment in exact proportions as used in topping of the tiles. The containers for the grout mix shall be suitably marked to relate it to the particular type and batch of tiles.

c) Mix: Underbed

The underbed for floor and similar horizontal surfaces shall be 1-part lime putty: 1 part surkhi: 2 parts coarse sand by weight mixed with sufficient water to form a stiff workable mass. For skirting and dado and all vertical surfaces it shall be about 12 mm thick and composed of 1-part cement and 3 parts coarse sand by weight.

d) Laying

The underbed mortar shall be evenly spread and brought to proper grade and consolidated to a smooth surface. The surface shall be roughened for better bond. Before the underbed had time to set and while it is still fairly moist but firm, cement shall be hand dusted over it or a cement slurry applied and the tiles shall immediately be placed upon and firmly pressed by wooden mallet on to the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The

joints between tiles shall be as close as possible and not more than 1.5 mm wide.

Special care shall be taken to check the level of the surface and the lines of the joints frequently so that they are perfect.

When tiles are required to be cut to match the dimensions these shall be sawn and edges rubbed smooth. The location of cut tiles shall be planned in advance and approval of the Engineer taken.

At the junction of horizontal surface with vertical surface the tiles on the former shall enter at least 12 mm under the latter.

After fixing, the floor shall be kept moist and allowed to mature undisturbed for 7 days. Heavy traffic shall not be allowed.

If desired dividing strips as specified under Clause 2.01.02(c) may be used for dividing the work into suitable panels.

e) Grinding and Polishing

Procedure shall be same as Clause 2.01.02(e). Grinding shall not commence earlier than 14 days after laying of tiles.

2.02.02 Chequered Tile Finish

The finish shall consist of manufactured gray or coloured cement tiles or terrazzo tiles with chequered face and an underbed laid over concrete or brick surface.

a) Thickness

Thickness shall be same as in clause 2.02.01 (a).

b) Tiles: Chequered

The tiles shall have chequers not less than 2.5 cm. c/c and not more than 5 cm. c/c. Depth of grooves shall be not less than 5 mm. The grooves shall be uniform and straight.

The tiles shall conform to clause 2.02.01 (b) except that these may have the topping in terrazzo or plain gray cement or colour pigment added to cement.

c) Under-bed
As per clause 2.02.01 (c).

d) Laying
As per clause 2.02.01 (d).

e) Grinding and Polishing

As per clause 2.02.01 (e) except that the tiles shall be ground and polished by hand and after laying taking special care in polishing the grooves properly and uniformly.

2.02.03 Glazed Tiles Finish

This finish shall be composed of glazed earthenware tiles with an underbed laid over a concrete or masonry base.

a) Thickness

The total thickness shall be between 20mm and 25mm including the underbed.

The tile finish on vertical surface shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the finish, to accommodate the specified thickness shall be done.

b) Tiles: Glazed

The tiles shall be of earthenware, covered with glaze white or coloured, plain or with designs, of 150 mm x 150 mm nominal sizes and 5.5 mm to 6 mm on thick unless otherwise specified. The tolerance shall be ± 1.5 mm for length and breadth and ± 0.5 mm for thickness specials like internal and external angles; beads, covers, cornices, corner pieces etc. shall match. The top surface of the tiles shall be glazed with a gloss or matt, unfading stable finish as desired by the Engineer. The tiles shall be flat and true to shape. The colour shall be uniform and fractured section shall be fine grained in textures, dense and homogeneous. The tiles shall be strong and free from flaws like cracks, craze, specks, crawling, etc. and other imperfections. The edge and the underside of the tiles shall be completely free from glaze and the underside shall have ribs or indentations for better anchorage with the fixing mortar.

The coloured tiles, when supplied, shall preferably come from one batch to avoid difference in colour.

c) Mix: Underbed

The mix for the underbed shall consist of 1-part cement and 3 parts coarse sand by weight mixed with sufficient water or any other mix if specified.

c) Laying
Same as clause 2.02.01 (d).

e) Finishing

The joints shall be cleaned and flush pointed with white cement and cured for 7 days by keeping it wet. The surface shall be cleaned with soap or suitable detergent, washed fully, and wiped with soft cloth to prevent scratching before handing over.

2.02.04 Tesserae Finish (Mosaic etc.)

This finish consists of manufactured vitreous, glass, ceramic or similar hard small pieces set in an underbed over a concrete or masonry surface, already laid.

a) Thickness

The total thickness including the underbed shall be between 16 mm & 25 mm.

b) Tesserae Finish

These shall usually be 6 mm thick small piece of ceramic vitreous china, tinted glass, or similar hard wearing, strong, and durable material in desired shapes and sizes and patterns.

The supply shall come in the desired pattern in full or sections conveniently for handling, stuck to pieces of strong thick paper on the surface to be exposed. The gum used for this purpose must be water soluble and non-staining. The sections shall be properly marked to avoid mistakes and master drawing shall be available at the site for guidance.

c) Mix: Underbed
Same as clause 2.02.03 (c)

d) Laying

The specification for laying if given by the manufacturer of the item shall be followed provided it is approved by the Engineer. Otherwise clause 2.02.03 (d) shall generally be followed. However, instead of gray cement the slurry shall be made with white cement to fix the panels. The paper-

mounted patterns in sections shall be carefully placed and pressed in position true to lines and levels. Earliest possible the paper shall be peeled off and surface examined and cleaned, joints flush pointed with white cement and cured for 7 days by keeping it wet.

2.02.05 Chemical Resistant Tiled Finish

This shall include all verities of special tiles used for specific chemical resistance function and an underbed over already laid concrete or masonry.

a) Tiles

The chemical resistant tiles shall be of the best indigenous Manufacture unless otherwise specified and shall be resistant to the chemical (both acid and alkali). The tiles shall have straight edges, uniform thickness, plain surface, uniform nonfading colour, and textures.

Usually the chemical resistant tiles shall not absorb water more than 2% by weight. The tiles shall have at least compression strength of 700 Kg/cm^2. The surface shall be abrasion resistant and durable.

b) Laying

The mortar used for setting or for underbed these tiles shall be durable, strong and chemical resistant epoxy mortar. The grout, which shall be to the full depth of tile, shall have equal chemical resistant properties. Joints shall be pointed if so desired. The setting and fixing shall be according to the manufacturer's specification approved by the Engineer.

2.02.06 Rubber, Vinyl, or Vinyl Asbestos Tiles Finish

This shall include various types of tiles manufactured from rubber, vinyl etc. set with an adhesive on concrete or masonry base. An underbed may be required to secure desirable surface and grade.

a) Thickness

The thickness of the tiles shall be as incorporated in drawing.

b) Tiles

Unless otherwise desired the tiles shall be squares of approved dimensions. The tolerance in dimensions shall be ± 1.5 mm.

The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or either physical defects which affect appearance or serviceability. All edges shall be cut true and square. The colour shall be nonfading and uniform in appearance, insoluble in water and resistant to alkalies, cleaning agents and usual floor polishes.

Each tile shall be marked on the back legibly and indelibly with manufacturer's trademark, the thickness, sizes, batch number, and date of manufacturer.

Tiles shall be delivered securely packed and stored in clean, dry well ventilated place at a temperature near about to that the tiles shall be called upon to stand ultimately.

Adhesive to be used for sticking the tiles shall be approved by the tile manufacturer. The adhesive shall have a short drying time and long life in addition to toughness.

c) Mix: Underbed

The underbed where required to make up the specified thickness or to give the required grade or to get the right type of surface shall be composed of 1 part like putty:1-part cement: 3 parts coarse sand mixed with just sufficient water to make it workable.

d) Laying

The tiles shall be kept in the room to be tiled for at least 24 hours to bring them to the same temperature as the room. For air-conditioned space, the air-conditioning shall be completed before tiling is taken up.

The surface to receive this finish shall be firm even textured but not too smooth, without undulations and other deficiencies. If an underbed is laid the same shall be cured for at least 7 days by keeping it moist and then fully dried.

The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil and grease if any shall be completely cleaned by use of detergent.

The adhesive shall be applied to fully dry surface in desired thickness uniformly. The adhesive shall also be applied to the backs and edges of the tiles and allowed to surface dry. The tiles shall be placed neatly on the surface exactly to the approved pattern and set with a suitable tool. If the edges tend to curl, weights are to be used to keep the edges down. Special care shall be taken to avoid formation of air pockets under the tiles. The

joints shall be very fine. Any adhesive squeezed out through the joints shall be removed immediately.

e) Finishing

If any adhesive mark is there on the surface a soft cloth soaked in solvent shall be used to wipe it off. The surface shall be cleaned with soft soap, dried, and polished with an approved type of polish just before handing over.

2.02.07 Stone Slab Finish: Marble, Stone, and Similar Fine Grained Stone including Kota stone

a) Thickness

The underbed shall be minimum 12 mm and average 20 mm thick. The slabs will be 20 mm thick.

b) Stone Slab

The stone slabs shall be made from selected stock, which is hard, sound, homogeneous and dense in texture and free from flaws. Angles and edges shall be true, square, and free from chipping and surface shall be plane. The slabs shall preferably be machine cut to the required dimensions. Tolerance of ± 5 mm in dimensions and ± 2 mm in thickness will be allowed. Unless specified the slabs shall be minimum 300 mm x 300 mm.

The stone slabs shall come from specific regions and in specified quality with top surface fine chisel dressed. All sides shall also be fine chisel dressed to the full depth to allow finest possible joints.

The slabs shall be delivered to the site well protected against damages and stored in dry place under cover.

c) Mix: Underbed
Same as clause 2.02.01 (c).

d) Laying

The sides and top surface of the slabs shall be machine rubbed or table rubbed with coarse sand stone and washed before laying.

The underbed mortar shall be evenly spread and brought to proper level on the area under each slab. The slab shall be laid over the underbed, pressed, and tapped down with wooden mallet to the proper level. The slab shall then be lifted and the underbed corrected as necessary and allowed to

stiffen a little. Next, thick cement slurry shall be spread over the surface. The edges of the slab shall be buttered with slurry of cement, gray / white / mixed with pigment matching the colour of the stone slabs. The slab shall

be gently laid and tapped with wooden mallet to bed properly to a very fine joint and to the required level. All surplus cement slurry shall be removed and the surface mopped clean with wet soft cloth. The laid finish shall be cured for 7 days by keeping it wet.

e) Polishing, Finishing

Fine chiselling shall be done to remove the slight undulations that usually exist at the joints. The polishing and finishing shall be done as specified under clause 2.02.01 (e). However, the joints shall be so fine in the case of stone slabs that grouting shall not be called for.

2.02.08 Stone Slab Finish: Sand Stone and Similar Coarse Grained Stone Finish

Generally, clause 2.02.07 shall be followed except that the workmanship and finish shall not be fine as which are explained hereunder.

The slabs shall be rough chiselled or fine chiselled as specified. Tolerance may be allowed upto ± 6 mm for rough finish, but no sharp unevenness and shall be allowed. For fine chiselling the unevenness shall be limited to ± 2 mm. The sides shall be chisel dressed at least to half slab depth so that the maximum deviation from straight line shall be within 25 mm. Beyond this depth the edge may be slightly splayed.

The joint thickness shall be kept limited to 5 mm in case of rough finish and 3 mm in case of fine finish unless wider joints are specified. The joints shall be grouted with white or coloured cement. If fine joints in the flooring are specified, the edges of slabs shall be cut in such a way that it shall form an inverted 'Y'.

3.00.00 ACCEPTANCE CRITERIA

The finish shall be checked specially for:

a) Level, Slope, Plumb as the case may be

b) Pattern and Symmetry

c) Alignment of joints, dividing strip etc.

d) Colour, texture

e) Surface finish

f) Thickness of joints

g) Details at edges, junctions etc.

h) Performance

i) Precautions specified for durability

4.00.00 I.S. CODES

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

IS: 777	:	Glazed earthenware tiles
IS: 1196	:	Code of practice for laying bitumen mastic flooring.
IS: 1197	:	Code of practice for laying of rubber floors
IS: 1237	:	Cement concrete flooring tiles
IS: 1443	:	Code of practice for laying and finishing of cement concrete flooring tiles.
IS: 2114	:	Code of practice for laying in situ terrazzo floor.
IS: 3461	:	PVC asbestos floor tiles
IS: 4860	:	Specification for acid resistant bricks
IS: 5518	:	Code of practice for laying of flexible PVC Sheet and tile flooring.
IS: 5491	:	Code of practice for laying in situ granolithic floor topping.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall be for the complete work (including dividing strips, Ironite, metals, tiles etc. if any) as per the schedule of items. Rates shall be applicable for application on horizontal and vertical surfaces at all elevations and for all types of work including stairs tread and riser, laying in desired pattern and panels, cost of specials (if any) rounding of corners, mouldings etc.

Rates shall be including provision of side shuttering (if required) for casting of floor in alternate panels and or without dividing strips.

5.02.00 Measurement

The finished surface shall be measured in Sqm for area unless otherwise specified. Deduction shall not be made for opening or embedded articles having area not exceeding 0.1 Sqm.

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SECTION - D

SUB-SECTION – D13

SHEET WORK IN ROOF AND SIDING

SPECIFICATION NO. PE-TS-999-600-C013

Maharatna Company

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
1.00.00	SCOPE	3
2.00.00	INSTALLATION	3
3.00.00	ACCEPTANCE CRITERIA	5
4.00.00	I.S. CODES	5
5.00.00	RATES AND MEASUREMENTS	6

SHEET WORK IN ROOF AND SIDING

1.00.00 SCOPE

This section covers supply, cutting & fabrication and erection of corrugated/plain asbestos, corrugated galvanized iron, aluminum, permanently colour coated troughed zinc-aluminium alloy coated M.S. sheet or other sheet for covering to roof and sides at various elevations as specified.

2.00.00 INSTALLATION

2.01.00 Storage of Materials

All materials shall be stored by the Contractor in proper way to prevent all damage.

2.02.00 Workmanship

The workmanship shall be according to best construction practice to give a watertight finish to the satisfaction of the Engineer. Fixing of gutters and down pipes shall be according to IS: 2527.

2.02.01 Asbestos Sheeting

Asbestos sheets of profiles as specified shall be fixed with minimum 150 mm end lap and side laps as per manufacturer's specification. Hook bolts or J-bolts shall be 8 mm dia. at 305 mm centres. Six (6) mm dia. galvanized iron seam bolt and nut with G.I. flat washers and bitumen washers shall be used for stiching ridge cappings, corner pieces, ventilators, north light curves etc.

2.02.02 C.G.I. Sheeting and Aluminium Sheeting

Side laps shall be 2 corrugations for roof and one corrugation for side sheeting. End laps shall be minimum 150 mm for roof and 100 mm for side sheeting. In ridges and hips where plain sheets are used, the end laps shall be minimum 100 mm. Holes in C.G.I. sheets shall preferably be made on the ground. The sheets should be placed on purlins/trestles and holes punched in the ridge of the corrugation from the outside inward for obtaining proper seating of limpet washers. Sheets shall be secured to sheet framing by 8 mm dia. galvanised iron hooks or J-bolts and maximum spacing of the bolts shall be 305 mm. The length of the hook or J-bolts shall be to suit the sections of the bearers. Sheets shall also be bolted at the ends at every third corrugation with 6 mm dia. galvanized iron seam bolts and G.I. flat washers and bituminous washers.

2.02.03 Fibre Glass Reinforced Plastic Sheeting

This shall be of thickness and profile as specified. Colour and light transmittance shall be as mentioned. Where used in conjunction with C.G.I. or asbestos sheeting, the end and side laps and fixing device shall be same as used for general sheeting. Where used in lieu of glass, the fixing shall be by means of timber or metal glazing beads. In all cases, the installation shall be completely watertight and able to withstand the designed wind-pressure.

2.02.04 PERMANENT COLOUR COATED (SANDWICHED INSULATED) METAL CLADDING SYSTEM

i. Troughed zinc-aluminium alloy coated (both sides) M.S. sheet having 0.6mm minimum thickness (or high tensile steel sheet having minimum yield strength of 350 Mpa of 0.5mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 150 gm/sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF_2) of Dry Film Thickness (DFT) 20 microns (minimum) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

ii. Galvanised M.S. sheets of minimum 0.6mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (minimum) over primer. Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanization shall not be less than 275 gm/sqm.

iii. The permanent colour coated sheet shall meet the general requirements of IS:14246 and shall conform to class 3 for the durability.

iv. Inner sheet shall be fixed directly to side runners and Z spacers made out of at least 2 mm thick galvanized steel sheet of grade 375 as per IS:277. Inner sheet shall be fixed at the rate not more than 1.50M centre to centre to hold the insulation and external sheeting. The fasteners shall be of high quality corrosion resistant grade of self tapping / self drilling type provided with suitable cap.

v. The insulation shall be of bonded mineral wool of minimum thickness 50mm conforming to IS:8183, having a density of 32 Kg/cum. for glass wool & 48 Kg/cum. for rock wool.

2.02.05 PERMANENT COLOUR COATED (NON-INSULATED) METAL CLADDING SYSTEM

i. Troughed zinc-aluminium alloy coated not less than 150 gm/sq.m M.S. sheets having 0.6 mm minimum thickness (or High tensile steel sheet having minimum yield strength of 350 Mpa of 0.5mm minimum thickness) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF_2 paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS:14246 and shall conform to class 3 for the durability.

ii. **FLASHING, CAPS, TRIM CLOSURES ETC.**

All flashings, trim closures caps etc. required for the metal cladding system shall be made out of plain sheets having same material and coating specification as mentioned above for the outer face of the sandwiched metal cladding.

3.00.00 ACCEPTANCE CRITERIA

The installations shall present a neat appearance and shall be checked for water tightness. The following shall be checked:

a) Side and end laps

b) Absence of cracks, holes or damages in sheet

c) Spacing of bolts

d) Provision of double washers (G.I. and asbestos or bituminous washers)

e) Proper installation of flashing.

4.00.00 I.S. CODE

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

IS: 3007 : Code of practice for laying of asbestos cement sheets.

IS: 2527 : Code of practice for fixing rainwater gutters and down pipes for roof drainage.

IS: 1626 : Specification for asbestos cement building pipes, gutters and fittings.

IS: 277 : Specification for galvanized steel sheets (plain and corrugated).

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall be unit rate for complete item described in "Schedule of Items" and shall include all wastage.

5.02.00 Measurement

Sheeting work in roof & sides shall be measured in Sq.M. for net area of the work done. Profiled sheeting shall be measured flat and not girthed. Opening less than 0.40 Sqm shall not be deducted. No extra shall be paid for extra labour in cutting and for wastage etc. No payment shall be made for laps, flashings, sealing, fasteners etc. in sheeting works.

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SECTION - D

SUB-SECTION – D14

SUSPENDED CEILING

SPECIFICATION NO. PE-TS-999-600-C014

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
1.00.00	SCOPE	3
2.00.00	INSTALLATION	3
3.00.00	SAMPLES	5
4.00.00	SHOP DRAWINGS	5
5.00.00	ACCEPTANCE CRITERIA	6
6.00.00	RATES AND MEASUREMENTS	6

SUSPENDED CEILING

1.00.00 SCOPE

This section covers supply and installation of suspended ceiling together with the suspension system as shown on drawing or specified in schedule of item with all materials, labour and equipments. The work shall also include providing of openings in the ceiling for lighting, air-conditioning diffusers etc. as shown on drawings or as instructed by the Engineer.

2.00.00 INSTALLATION

2.01.00 Suspension System

2.01.01 General

Suspension system shall consist of the grid supporting the ceiling panels, intermediate runner supports for the grid if any and hangers, wall angles etc. required to suspend the grid or the runners from structural works, slabs and beams.

All members of the suspension system shall be of sufficient strength and rigidity to carry, the ceiling boards or sheets in a true and level plane without exceeding a deflection of 1/360th of their span. All joints in ceiling panels shall run straight and cross joint shall be at perfect right angles. Angle moulds where shown on drawings shall be securely fixed to walls. All drillings of structural concrete and installation of suitable anchoring device for installation including welding of the suspension system shall be included in the rate. All M.S. sections used for supports etc. shall be given one coat of synthetic enamel paint over a coat of red lead primer.

2.01.02 Metal Grid Suspension System

Aluminium grid ceiling system shall be “Bead lock” as manufactured by W A Beard shell and Co. Pvt. Ltd. or Ajit India Limited or approved equal. Steel grid ceiling system shall be 'Jolly Snap Grid' as manufactured by Jolly Board Limited or approved equal.

Steel tees as intermediate members and steel channels, as end pieces will be assembled in the form of grid. Size of tees and channels shall be as required.

The cross-tees shall intersect main tee runners in pattern shown on drawing and positively locked together with intersection members. All perimeter areas shall have tee runners fixed to vertical wall surfaces and end channels shall be fixed to runners leaving return air space between vertical wall and channels,

unless otherwise shown on drawings. Angle cleats or other suitable fixing device shall be fixed to the structural beams above for fixing of hangers. Main runners shall be hung by M.S. flats, angles, rods or 12G or heavier galvanized tie wire hangers at maximum 1.2 metre centres. Extra hangers shall be provided at light fixtures that are supported from the ceiling system. The spacing of main and cross runners shall be as shown on drawings. Turnbuckles shall be provided in M.S. rods for adjustment in levels.

2.02.00 Ceiling Panels

2.02.01 Material

Ceiling panels shall be best quality material in thickness and properties called for in the "Schedule of items". The Contractor shall submit test certificates to the Engineer for approval before bulk supply. The ceiling panels may be of following type:

a) Plaster of Paris board (decorative)

b) Expanded polystyrene insulation board with plastic fascia.

c) Fibre Insulation board.

d) Bonded wooden particle board (Plain and decorative)

e) Glass fibre reinforced polystyrene sheets.

f) Flat asbestos sheets (with plastic fascia).

2.02.02 Installation of Ceiling Panels

Installation of Ceiling panels shall be strictly as per manufacturer's instruction.

For concealed grid system, tiles shall be fixed to the supporting grid in manner shown on drawing or as specified by the manufacturer. Where V joints in tiles are called for in drawings, these shall be in true lines. Where flush surface is required, the joints shall be filled with approved filler material and finished to give a neat uniform surface. Special care shall be taken to neatly finish the ceiling at junctions with walls, light fixtures, diffusers etc.

2.02.03 Aluminium Lineal Ceiling System

Aluminium lineal ceiling system shall be "Luxalon 84C" or approved equal and the installation shall be strictly as per manufacturer's instruction/ specification subject to approval of the Engineer.

Aluminium lineal ceiling shall comprise of plain panels, 84 mm wide and 12.5 mm deep with a 23.9 mm recessed flange, roll formed out of 0.5 mm thick aluminium alloy panels stove enamelled on both sides, fixed on roll-formed carriers made of enamelled 0.95 mm thick aluminium, 32 mm wide and 39 mm deep with prongs to hold panels in the module of 100mm, at maximum spacing 1.2 M centre to centre. The carriers shall be suspended from roof by 4 mm dia. galvanised steel wire hangers with special height adjustment clips made out of spring steel at maximum spacing of 1.2 M c/c. Hangers shall be fixed to roof by 'J' hooks and nylon inserts. 25 mm thick resin bonded mineral wool (spintex 300 or equivalent) insulation bound in polythene shall be laid on top of panels. Lineal ceiling shall be fixed in pattern as per detailed drawings.

3.00.00 SAMPLES

Samples of Ceiling panels and metal suspension system components as noted below shall be submitted for Engineer's approval:

Panels : 3 samples approximately 300 mm square/long each

Suspension System : 3 samples of short length: each of main and secondary system

4.00.00 SHOP DRAWINGS

Shop drawings shall be submitted for approval as required and approval shall be obtained prior to delivery of suspended ceiling components. Shop drawings shall be co-coordinated with all related work and shall show the following information:

a) A reflected ceiling plan of areas indicated to receive the ceiling showing electrical and mechanical features.

b) Typical Intermediate framing for support where required.

c) Hanger fastening details.

d) Panels - unit support at ceiling penetrations.

e) Details of splicing method for main and cross runners.

f) A table indicating load bearing capacity of main and cross runner

g) A note stating that the suspension system member furnished will not deflect more than 1/360 of the span under the indicated loading.

5.00.00 ACCEPTANCE CRITERIA

Finished ceiling shall be at the correct plane and present a pleasing and uniform appearance, free from, sags, warps, disfigured, or damaged board. Cut-outs for light fixtures, diffusers etc. shall be of exact dimensions and in exact locations.

6.00.00 RATES AND MEASUREMENT

6.01.00 Rates

Rates shall be for the complete item called for in the "Schedule of Items". No extra payment will be made for alignment and adjustment of lighting fixtures, air-conditioning diffusers, access panels etc. The rate shall include all cutting and wastage from standard size sheets, runners/carries etc.

6.02.00 Measurement

Actual area of work shall be measured in Sqm correct to second place of decimal. However, no deduction will be made for opening upto 0.25 Sqm. each in area.

VOLUME: II B

SECTION - D

SUB-SECTION – D15

WATER SUPPLY, DRAINAGE AND SANITATION

SPECIFICATION NO. PE-TS-999-600-C015

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
1.00.00	SCOPE	3
2.00.00	MATERIAL	3
3.00.00	INSTALLATION	6
4.00.00	TESTING AND ACCEPTANCE CRITERIA	17
5.00.00	I.S. CODES	20
6.00.00	RATE AND MEASUREMENT	21

WATER SUPPLY, DRAINAGE AND SANITATION

1.00.00 SCOPE

This section covers supply of all materials labour and incidentals required for supply, laying and installation of under/over ground pipes for water supply, drainage and sanitation with all fittings, fixtures and jointing, construction of ancillary works like manholes, drop connections, gully chambers, septic tank, soak pits, surface drain etc.

The supply and installation of water supply/sanitation fixtures and accessories like water closets, urinals, wash basins, sinks, mirrors, shelves, towel rail, soap container etc. with all fittings, fixtures, water supply/sanitation pipes and water storage tanks etc.

2.00.00 MATERIAL

All materials, fittings, fixtures, and appliances shall be of the best quality conforming to relevant Indian Standard and shall be procured from approved manufacturers. Unless specifically allowed by the Engineer, the Contractor shall submit samples of fittings and fixtures, which will be retained by him for comparison when bulk supplies are received at the site. Ultimate choice of type, model, and manufacturer lies completely with the Engineer.

It shall be the responsibility of the Contractor to procure the materials selected by the Engineer. Hence orders are to be placed with the manufacturers in time, so that the materials are available at the site well ahead of their requirement.

The materials brought to the site, shall be stored in a separate secured enclosure away from the building materials. Pipe threads, sockets, and similar items shall be specially protected till final installation. Brass and other expansive items shall be kept under lock and key. Fragile items shall be checked thoroughly when received at the site and items found damaged shall not be retained at the site.

2.01.01 Pipes and Pipe Fittings

For water supply, galvanised mild steel pipe of medium grade confirming to IS: 1239 shall be used. The galvanising shall not be less than 400gm/sqm of pipe surface area. Galvanising shall be smooth and shall be subjected to testing as per IS: 2633 for uniformity of coating. The zinc coating shall be free from defects.

For Roof drainage and building sanitation works following type of pipe are coved in this Section:

a) Cast Iron pipe

b) Steel pipe (lined, coated with bituminous composition, out coated with cement concrete or mortar or galvanized)

c) Concrete pipe

d) Asbestos cement pipe

e) PVC pipe

f) Stoneware pipe

g) Vitrified pipe

h) Lead pipe (not to be used for portable water)

2.02.01 Fixtures

All material, fittings, fixtures, appliances, accessories shall be of approved quality and shall be procured from reputed brands like Hindustan/Pasriware/ Cera or equivalent or as approved by Engineer. The bidder shall procure the fixtures from the above named reputed manufacturers and shall mention in his bid the type & make of the fixtures he intends to use.

All items brought to the site must bear the manufacturer's identification mark. Procurements shall be made well in advance and should get inspected & approved immediately by the Engineer. All fixtures shall be adequately protected, covered, and plugged till handing over.

All fittings, gratings, fasteners, unless specified otherwise, shall be chromium plated. The chromium plating shall be of grade-2 (10micron thickness) confirming to IS: 4827. Powder coating shall be of approved colour and shall have minimum thickness (DFT) of 20micron. Stainless steel accessories shall be of grade SS-304 and from reputed manufacturer (like Salem Steel) and shall be polished bright finish.

Unless specified in the contract the fixtures shall be as specified hereinafter.

Water closet

a) **European type**

It shall consist of European type glazed vitreous china basin (confirming to IS: 2556, part-II), with siphon open front solid plastic seat and plastic cover, low level glazed stoneware flushing cistern with valve less fittings, supply connections and necessary fittings. All fittings shall be chromium plated. Colour of basin, cistern, seat and cover shall be as approved by the Engineer.

b) **Squatting type**

It shall consist of Orissa pattern glazed vitreous china squatting pan with integral foot rests (confirming to IS:2556, part-III) and high level cast iron flushing cistern with valve less fittings, supply connections and necessary fittings. All fittings shall be chromium plated. The flushing cistern shall be painted as specified by the Engineer.

Urinals

It shall consist of wall type glazed vitreous china urinals (conforming to IS:2556), cast iron automatic flushing cistern complete with supply connections, flush pipe, lead pipes, gratings, traps and all other necessary fittings. Frequency of automatic flushing shall be approximately once every five minutes. For every four urinals (maximum) located together may be served by one cistern of adequately capacity. All fittings shall be chromium plated.

Wash Basin

It shall be made of glazed vitreous china conforming to IS:2556, part-IV. The basin shall be flat back, wall hung by painted cast-iron brackets and complete with hot and cold CP brass faucets with nylon washers, PVC connection pipe with CP brass nuts, CP brass chain with rubber plug, 32mm dia. Chromium plated brass waste of standard pattern, 32mm dia. CP brass trap union complete with necessary fittings.

Sink

It shall be made of glazed vitreous china conforming to IS:2556, Part-V. It shall be wall hung by painted cast iron brackets and complete with one CP brass faucet with nylon washers, PVC connection pipe with CP brass nuts, CP brass chain with rubber plug, 40mm dia. chromium plated brass waste of standard pattern, 40mm dia. CP brass trap union complete with necessary fittings.

Bathroom mirror

It shall be made of the best quality 6 mm thick glass and produced by a reputed mirror manufacturer. It shall be wall mounted with adjustable revolving brackets. The brackets, screws, and other fittings shall be chromium plated.

Glass shelves

Class shelves shall consist of 6 mm thick clear glass with guardrails and shall be wall mounted with brackets. All brackets, guardrails, and screws shall be chromium plated.

Towel rail

Towel rails shall be 20 mm dia chromium plated MS pipes wall mounted with steel brackets. The brackets, screws etc. shall also be chromium plated.

Soap holder

It shall be made of chromium plated strong members. The holders shall be wall mounted with chromium-plated screws.

Liquid Soap Dispenser

It shall be round and easily revolving with removable threaded nozzle. The body, bracket for wall mounting and screws shall be chromium plated.

Toilet roll bolder

It shall be made of glazed vitreous china with suitable cover cum cutter. Wall mounting screw shall be chromium plated.

Valve, cocks, Taps

All valves, stop cocks, taps etc. shall conform to relevant Indian standard specification and shall be of best quality from approved manufacturers. These shall be suitable for normal working pressures. Nominal size and material shall be as required / specified.

2.03.00 Water Storage Tank

Water storage tank shall be PVC of approved brand and make (Syntex or equivalent). Reservoirs made of concrete masonry or fabricated steel shall be covered by respective work specifications.

3.00.00 INSTALLATION

3.01.00 General

Basic layouts may be available in the drawings provided, the details might have to be supplemented by the Contractor and get the approval of the Engineer before installation. Special attention shall be given to economise the layout. Symmetry of layout is very important. Fittings meant for operation shall be located and oriented to allow easy reach and operation. Maintenance, repairs, and replacements of pipes, fittings, and fixtures must be conveniently possible. All pipe lines, locations of fittings and fixtures, etc. shall be as per drawings or as directed by the Engineer. Correctness of lines, plumb, orientation, symmetry, and levels shall be strictly ensured. All items shall be fully secured against movement in any direction and so located as to allow easy maintenance.

All pipelines, fittings, and fixtures shall be installed leak proof. When the works under scope of this specification linked up with works executed by others, the connections shall be such as to prevent any splashing or spilling or emission of foul odour and gases.

3.02.00 Portable water supply Pipe Lines

3.02.01 Laying

In addition to fulfilling the functional requirements all pipelines shall be laid true to line, plumb and level and shall run on the surface of the walls, ceiling or in chases. Any deviation shall need approval of the Engineer. Meticulous care shall be taken to avoid chances of airlock and water hammer.

Pipes shall be laid on continuous unyielding surface or on reliable supports at least one near each joint and spacing as directed by the Engineer. The support must be strong, neat and shall have provisions for securing the pipes in every direction and easy maintenance. All pipes used for water supply should be thoroughly and efficiently disinfected before taken in to use.

3.02.02 Back Flow

The layout of pipe work shall be such that there is no possibility of back flow towards the source of supply from any cistern or appliances, whether by siphonage or otherwise. All pipe works shall be so laid or fixed and maintained as to be and to remain completely watertight, thereby avoiding waste of water, damage of property and the risk of contamination of the water conveyed.

3.02.03 Contamination

There shall be no cross connection whatsoever between a pipe/fitting for conveying or containing wholesome water and a pipe/fitting for containing impure water or water liable to contamination or of uncertain quality of water which has been used for any other purpose. No piping shall be laid or fixed so as to pass into or through any sewer, scour outlet or drain or any manhole connected therewith.

3.02.04 Underground Piping

Underground piping shall be laid at such a depth that it is not likely to be damaged by traffic and other loads and frost, where applicable. The size and depth of the trench shall be as approved by the Engineer. Back filling shall be done with selected fine earth, unless otherwise permitted, in 150 mm layers and carefully consolidated. Special care shall be taken while filling in the vicinity of the pipe to avoid damage. Before backfilling, the laid pipe shall be fully tested and approved.

Where the pipe rests on rock it may be bedded on a layer of fine selected material or concrete to avoid local point support. The trench shall be so treated by gradient and filling in the area that it does not act as a drainage channel.

3.02.05 Concealed Piping

Where desired by the Engineer or shown on the drawings the pipes shall be concealed in masonry or concrete of the structure. The Contractor may co-ordinate with the building Contractor for leaving the chases, openings, and conduits as necessary. However, the Contractor will rectify if required the chases, openings, and conduits, supplement and make good after laying and testing of the concealed pipelines.

3.02.06 Jointing of Pipes

All G.I. pipes shall be properly thread/weld jointed and made completely water tight and durable. Burr from the joints shall be removed after screwing. Union joints shall be provided for all required location to facilitate maintenance.

3.02.07 Painting

Where required, underground G.I. pipes shall be given 2 coats of bituminous paint on the outside after laying. When painting is to be done above ground G.I. pipes shall be given one coat of red lead or zinc chromate primer and top coats shall be minimum 2 coats of best quality paint as specified.

3.03.00 RAINWATER DOWN COMERS

3.03.01 Pipes

Rainwater down comers shall be standard Cast Iron or Asbestos Cement Pipes. In case where specifically desired, M.S. pipes may also be used. M.S. pipes shall be painted outside with two coats of anticorrosive paints under a coat of primer.

Rainwater down comers shall run along and be secured to walls, columns etc. Where desired by the Engineer these may have to be installed in chases cut in the structure. All pipes shall be well secured and supported by adequately strong brackets. The brackets may be wrought iron clevis type, split ring type, or perforated strap iron type as approved by the Engineer. For vertical runs each pipe shall hang freely on its brackets fixed just below the socket. Suitable spacer blocks shall be provided against the vertical surface to which the pipe is fixed.

All bends and junctions shall be supplied with watertight cleanouts.

Roof and floor drains and yard gullies shall be installed, if required, by cutting into the structure and grouted with 1:2:4 cement concrete. All gutters shall be provided with removable gratings.

All horizontal pipes shall have a minimum fall of 1 in 100.

3.03.02 Khurras

The khurras shall be constructed before the work in parapet wall is taken up and it shall be 45x45 cm in size, unless otherwise specified and shall be formed of cement concrete of M-20 grade.

3.03.03 Gutters

The gutters shall be made of G.I. or A.C and procured from reputed specialised manufacturers. Each section shall be sufficiently rigid, edges and corners straight and the slopes perfectly uniform. G.I. gutters shall have the edges strengthened by suitable means.

Unless noted otherwise the gutters shall have a minimum fall of 1 in 120. Adequate number of string supports shall be provided so that there is no sagging even when the gutter is full. Each joint must have a support. Unless otherwise specified the supports shall be fabricated M.S. brackets. All junctions shall be thoroughly watertight. The joints may be made by riveting, bolting or soldering. All joints between successive lengths of gutters shall

have on overlap of at least 5 cm. The drop in the overlap shall always be in the direction of the fall of the gutter. Ends of gutters shall be closed watertight. Junction with rainwater down comers shall be made fully watertight and secured.

3.04.00 SOIL AND DRAINAGE PIPES

3.04.01 Gradients

If not specified, the minimum gradients of soil and drainage pipeline shall be as follows:

100 mm nominal dia.	:	1 in 35
150 mm nominal dia.	:	1 in 65
230 mm nominal dia.	:	1 in 120
300 mm nominal dia.	:	1 in 200

3.04.02 Relation with water supply pipelines

Unless specifically cleared by the Engineer, under no circumstances shall drainage and sewer pipes be allowed to come close to water supply pipelines.

3.04.03 Laying

Each separate pipe shall be individually set for line and for level. Where lengths of sewer or drain pipes are laid in trench, properly painted sight rails shall be fixed across the trench at a height, equal to length of the boning rod to be used, above the required invert level of the drain or sewer at the point where the sight is fixed. More sight rails shall be required at manholes, change of gradient and intermediate positions if the distance for sighting is more than 50 ft. apart. The excavation shall be boned in at least once in every 6 ft. The foot of the boning rod shall be set on a block of wood of the exact, thickness of the wall of the pipe. Each pipe shall be separately and accurately boned between sight rails.

3.04.04 Support and Protection of Pipelines

All pipes shall be laid with sockets leading uphill. Preferably the pipe shall rest on solid and even foundations for the full length of the barrel. However, the pipe manufacturer's instruction as approved by the Engineer shall be followed in the matter of support and jointing.

To achieve full and continuous support, concrete for bedding and packing is the best. Where pipes are not bedded on concrete, the floor shall be left slightly high and carefully placed so that the pipe barrels rest on undisturbed ground. If anywhere the excavation has been carried too low packing shall be

done in concrete. Where laid on rock or very hard ground which cannot be easily excavated to a smooth surface, the pipes shall be laid on a cradle of fine concrete floor of gravel and crushed stone over laid with concrete or on a well consolidated gravel and crushed stone bed as desired by the Engineer. PVC or similar pipes shall be laid directly on stable soil and packed with selected soil.

The minimum support and protection for glazed stoneware pipes shall be as follows:

a) When cover is less than 2 metre below ground level and where pipes are unavoidably exposed above ground surface, the pipes shall be completely encased or surrounded with concrete.

b) Where pipes are laid on soft soil with the maximum water table laying at the invert of the pipe, the sewer shall be bedded on concrete.

c) Where the pipes have to be laid on soft soil with the maximum water table rising above the invert of the pipe, but below the top of the barrel, the pipe sewer shall be haunched.

d) Where maximum water table is likely to rise above the top of the barrel or wherever the pipe is laid on soft soil the pipe sewers shall be completely encased or surrounded with concrete.

Vitrified clay pipes shall be laid on a bed of 150 mm thick cement concrete (1:3:6) nominal mix by volume.

Cast iron pipes and concrete pipes may be supported on suitable concrete or brick support, where specified. The supports shall be unyielding and strong enough. At least one support shall be located close to ends. Spacing of intermediate supports shall be as decided by the Engineer. Pipes shall be secured to the supports by approved means.

Anchoring of pipes where necessary shall be achieved by suitable concrete encasing designed for the expected thrust.

3.04.05 Entry into structures

For entry of the pipe lines into any building of structure suitable conduits under the structure or sleeves shall be used. The conduits and sleeves shall be such as to allow easy repairs and replacement of the pipes. When openings or chases are required to be made in the structure for entry of pipelines, locations and sizes shall be marked and checked by the Engineer. After laying of the pipeline the openings and chases shall be mended.

3.04.06 Ducts

Where solid, waste and ventilating pipes are accommodated in ducts, access to cleaning areas shall be provided. Connection to drain shall be through a gully with sealed cover to guard against ingress of sewer gas, vermin, or backflow.

3.04.07 Traps and Ventilating Pipes

Pipes are carrying off the waste from water closets and waste water and overflow water from baths, wash basins, sinks to drains shall be trapped immediately beneath such fixtures. Traps shall have minimum water seal of 50 mm and shall be ventilated whenever such ventilation is necessary to maintain water seal of the trap. Ventilating pipes shall be carried up vertically from the drain to a height of at least 600 mm above the outer covering of the roof of the building or as shown on drawings. All vertical ventilating, anti-syphonage and similar pipe shall be covered on top with a cowl. The cowl shall be made of C. I. unless desired otherwise by the Engineer.

3.04.08 Manhole & Inspection Chambers

At every change of alignment, gradient or diameter there shall be a manhole or inspection chamber. The maximum distance between manholes shall be 30 meter unless specially permitted otherwise. However, for truck route (for pipes above 900 mm dia.) this distance can be increased to 45 M. The distance between manhole or inspection chamber and gully chamber shall not exceed 6 metres unless desired otherwise provision of IS: 4111 (Part-1) shall be followed for construction of a manhole. Manhole shall be constructed so as to be watertight under test. The change in alignment shall be carried out in such a manner as to provide no lodgement for any splashing in case of accidental flashing of the chamber. The channel or drain at the bottom of chamber shall be plastered with 1:2 cement, sand mortar and finished smooth to the grade. The channels and drains shall be shaped and laid to provide smooth flow.

Connecting to existing sewer lines shall be through a manhole.

Unless otherwise specified, 560 mm dia. circular cast iron manhole cover with frame, heavy-duty, conforming to IS: 1726 shall be provided. The covers shall be close fittings so as to prevent gases from coming out.

3.04.09 Cutting of Pipes

Manufacturer's instructions shall be followed for cutting of pipes where necessary. Suitable and approved tools shall be used for the cutting so as to leave surface clean and square to the axis of the pipe.

3.04.10 Jointing

Jointing of pipes shall be so planned as to avoid completely any movement or strain to the joints already made. If any joint is suspected to be damaged it shall be opened out and redone.

All joints between pipes, pipes and fittings and manholes shall be gas-tight when above ground and watertight when underground. Method of jointing shall be as per instructions of the pipe and fittings manufacturer and as approved by the Engineer. However, in the absence of any instruction available from the manufacturer the methods as detailed hereunder shall be used.

a) Cast Iron Pipes

Socket and spigot pipes shall be jointed by the cast lead joints. The spigot shall be centred in the socket of the pipe by tightly caulking in sufficient turns of tarred gasket or hemp yarn to have unfilled half the depth of socket. When the gasket or hemp yarn has been caulked tightly a jointing shall be placed round the barrel and tightened against the face of the socket to prevent airlock. Molten lead shall then be poured in to fill the remainder of the socket and caulked with suitable tools right round the joint to make up for shrinkage of the molten metal on cooling and shall be finished 3 mm behind the socket face.

Joints in cast iron pipes with special jointing arrangements like 'Tyton' Joints etc. shall follow the instructions of the manufactures.

In special cases if flanged joints are accepted by the Engineer the joints shall be made leak proof by inserting approved type of rubber gaskets. The bolts shall be secured in stages to avoid uneven strain.

b) Concrete Pipes

Jointing of concrete pipes shall be generally of rigid type. Unless otherwise stated collar type joint shall be provided. IS: 783 shall be followed for general guidance.

The two adjoining pipes shall be butted against each other and adjoined in correct position. The collar shall then be slipped over the joint, covering equally both the pipes. The angular space shall be filled with stiff mixture of cement mortar 1:2 (1 cement: 2 sand) which shall be rammed with caulking tool. After a day’s work, any extraneous material shall be removed from the inside of the pipe and the newly made joint shall be cured for 7 days.

c) Glazed Stoneware Pipes

Tarred gasket or hemp yarn soaked in thick cement slurry shall first be placed round the spigot of each pipe and the spigot shall then be placed into the socket of the pipe previously laid. The pipe shall then be adjusted and fixed in the correct position and the gasket caulked tightly so as not to fill more than 1/4 of the total depth of the socket. The remainder of the socket shall be filled with a stiff mixture of cement mortar 1:1 (1 cement: 1 sand). A fillet shall be formed round the joint with a trowel, forming an angle of 45 deg. with the barrel of the pipe. The newly made joints shall be protected, until set and shall be cured by covering with damp cloth or other suitable materials.

d) Vitrified clay pipes

The vitrified clay pipe shall be made from refractory clay mixed with crushed pottery and stone and burnt at a high temperature. These shall be hard, compact, and glazed to make them acid resistant and impervious, and shall be obtained from approved manufacturer.

Special care shall be taken in handling these pipes. The pipes shall not be jointed until the earth has been partly refilled over the portion of the pipe between the joint holes. Before laying the second pipe, the socket of the first pipe laid shall be thinly painted all round on the inside with cement slurry (1 part of cement and 2 parts of clean, sharp sand). A ring of rope yarn (closely twisted hemp or jute) dipped in neat cement paste or tar or bitumen, shall be inserted in the socket of pipe and driven home with caulking tools. The rope shall fully encircle the spigot with a slight overlap and shall not occupy more than one-fourth of the total depth of the socket. Where the spigot end of the pipe is made for receiving the gasket, it shall be wrapped with two or three turns of tarred spun, as close to the end as possible, before inserting into the socket. The joint shall then be completely filled with cement mortar (1:1), which shall have very little water. A fillet shall be formed round the joint with trowel, forming an angle of 45 degrees with the outside pipe. Special care shall be taken so that any excess mortar etc. left inside the pipe joints is neatly cleaned off immediately after each joint is made. A semi-circular wooden scrapper or a rubber disc to which a long handle is fixed could be used for this purpose.

e) Lead Pipes

The joints in lead pipes shall be made as wiped solder joint. The minimum and the maximum length of the wiped solder joints shall be 8 cm. and 9 cm. respectively. The solders shall generally consist of two parts of lead and one part of tin.

f) Polyethylene Pipes

The joints shall be thermo welded or bolted as per manufacturer's instructions.

g) Jointing Cast Iron Pipes with Stoneware Pipes

Where any cast iron drain pipe, ventilating pipe or trap is connected with a stoneware or semi-vitrified waste pipe, the beaded spigot end of such cast iron drain pipe, waste or ventilating pipe or trap shall be inserted into a socket of such stoneware pipe and the joint made with mortar consisting of one part of cement and one part of clean sand after placing a ratted gasket or hemp yarn soaked in neat cement slurry round the joint and inserted in it by means of a caulking tool.

h) Jointing Stoneware with Cast Iron Pipes

Where any water closet pan or earth ware trap connected to such a pan is to be jointed with a cast iron soil pipe, the joint between the stoneware spigot and the cast iron socket shall always be of a flexible nature. Such joint shall be made with a mixture of bitumen and chopped asbestos fibre.

3.04.11 Trenches and other excavations

Width of the trench at the bottom shall be such as to provide 200 mm clearance on either side of the pipe for facility of laying and jointing.

Excavated material shall be stacked sufficiently away from the edge of the trench and the side of the spoil bank shall not be allowed to endanger the stability of the excavation. Spoil may be carted away and used for filling the trench behind the work.

Turf, top soil or other surface material shall be set aside, turf being carefully rolled and stacked for use in reinstatement.

All excavation shall be properly timbered, where necessary.

Efficient arrangements for dewatering during excavation and keeping it dry till backfilling shall be made to the satisfaction of the Engineer. Sumps for dewatering shall be located away from the pipe layout.

Where the excavation proceeds through roads necessary permissions shall be secured by the Contractors from the appropriate authorities.

Special care shall be taken not to damage underground services, cables etc. These when exposed shall be kept adequately supported till the trench is backfilled.

The backfilling shall be done only after the pipeline has been tested and approved by the Engineer. Special care shall be taken under and sides of the pipe during hand packing with selected material. At least 300 mm over the pipe shall also be filled with soft earth or sand. Consolidation shall be done in 150 mm layers. The surface water shall be prevented from getting into the filled up trench. Traffic shall not be inconvenienced by heaping up unduly the backfilling material to compensate future settlement. All future settlements shall be made good regularly to minimize inconvenience of traffic where applicable.

3.04.12 Protection

Open end of each pipe shall be protected during installation by suitable covers or plugs so that the ends, threads, sockets, or spigot are not damaged and no foreign material can find its way into the pipeline. Fittings and fixtures liable to be misused or stolen during the construction phase shall be fitted only before testing and handing over.

3.05.00 WATER STORAGE TANKS

Overhead/loft type water storage tank shall be made of PVC. These tanks shall be provided for each toilet block and placed on the roof/loft of the building. Tank shall be installed with proper supports and anchorage for applicable wind and seismic condition. Installation of tank shall be carried out according to the recommendation of IS: 12701. These tanks shall rest preferable on flat surface so as to distribute the load evenly. The tank shall be leak-proof and water tight.

The outlet pipe shall be 50 mm above the bottom of the tank and provided preferably with strainers. The wash out or draining pipe shall be connected at the lowest point and flush with bottom of tank.

Tank shall be provided with all fittings for inlet, outlet, overflow pipes and ball valves.

3.06.00 SEPTIC TANK AND EFFLUENT DISPOSAL

3.06.01 Septic tank

Septic tank shall consist of the tank itself with inlet and outlets there from complete with all necessary earthwork and backfilling. The details of septic tank shall be as shown on drawings. This item shall also include ventilating

pipe of at least 100 m dia. whose top shall he provided with a suitable mosquito proof wire mesh and cowl. Ventilating pipe shall extend to a height of about 2 meter when the septic tank is at least 15 meter away from the nearest building and to a height of 2 meter above the top of building when it is located closer than 15 meter. Ventilating pipes can be connected to the normal soil ventilating system of the building where allowed.

3.06.02 Effluent Disposal

The effluent from the septic tank shall be disposed by allowing it into an open channel or a body of water if the concerned authority approves or into a soak pit for absorption by soil or shall be allowed to be absorbed by soil through open jointed SW pipes laid in a trench filled with broken bricks.

3.06.03 Soak pit

The soak pit shall be complete. It shall consist of a 900 mm dia. pit 1000 mm in depth below the invert level of the inlet pipe. The pit shall be lined with stone; brick or concrete blocks set in cement mortar (1:6) and filled with brickbats. Inlet pipe shall be taken down to a depth of 900 mm from the top as an anti-mosquito measure.

3.06.04 Open joined SW Pipe/dispersion trenches

Minimum dia. of the SW pipes shall be 150 mm nominal. The trench for laying the pipes shall be a minimum 600 x 600 mm. The joints of the pipes shall be left unsealed. The entire length of the pipe within the trench shall be buried in a 250 mm layer gravel or crushed stone of uniform size. On top of gravel/crushed stone layer is a 150 mm bed of well-graded coarse aggregate. Ordinary soil is used for filling the top of trench.

3.06.05 Commissioning septic tank

After the septic tank has been proved watertight and the sewage system is checked the tank shall be filled with water to its outlet level before the sewage is let into the tank. It shall be seeded with well digested sludge obtained from septic tank or sludge digestion tank. In the absence of digested sludge, a small quantity of decaying organic matter such as digested cow-dung may be introduced.

3.07.00 Related Works

All works, like earthwork, masonry, concrete, steelwork, cutting holes, chases, repairs and rectification associated directly with installation of water supply and sanitation systems shall come under scope of the Contractor unless specifically excluded. These works are not detailed out in this Section.

3.08.00 Regulation

The work which is required to be carried out under this section, shall be executed by a licensed Plumber only (engaged by the Contractor) and he shall obtain all necessary sanctions, permissions, certificates etc., from Municipal and/or other Local Authorities and shall abide by all the rules of such Authorities.

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 Inspection Before installation

All pipes, fittings, and appliance shall be inspected, before delivery at the site to see whether they conform to accepted standards. The pipes and fittings shall be inspected on site before laying and shall be sounded to disclose cracks. Any defective items shall be clearly marked as rejected and forthwith removed from the site.

4.02.00 Testing of Water Supply pipe line

4.02.01 Testing of Mains After Laying

After laying and jointing, the main shall be slowly and carefully charged with water, so that all air is expelled from the main by providing a 25 mm inlet with a stop-cock, allowed to stand full of water for a few days if time permits, and then tested under pressure. The test pressure shall be 5 Kg/sq.cm or double the maximum working pressure, whichever is greater. The pressure shall be applied by means of a manually operated test pump, or in the case of long mains or mains of a large diameter, by a power driven test pump, provided that the pump is not left unattached. In either case due precaution shall be taken to ensure that the required test pressure is not exceeded. Pressure gauges shall be accurate and shall preferably have been recalibrated before the test. The pump having been stopped, the test pressure shall maintain itself without measurable less for at least five minutes. The end of the main shall be closed by fitting a watertight expanding plug and the plug shall be secured by struts to resist the end thrust of the water pressure in the mains.

4.02.02 Testing of Service Pipes and Fittings

The service pipes shall be slowly and carefully charged with water allowing all air to escape avoiding all shock or water hammer. The service pipe shall then be inspected under working conditions of pressure and flow. When all draw-off taps are closed, the service pipes shall be absolutely watertight. All piping, fittings, and appliances shall be checked for satisfactory support and protection from damage, corrosion, and frost.

4.03.00 Testing of Drain and Sewerage Pipelines

All soil pipes, waste pipes, ventilating pipes and all other pipes, when above ground, shall be gas tight. All sewers and drainpipes laid below ground shall be tested water tight. The method of actual tests shall be decided by the Engineer. All test data shall be recorded and submitted to the Engineer for review and instruction. The Engineer's discretion regarding tolerance shall be final.

General guidance for the tests are given below:

a) Smoke test

All soil pipes, waste pipes and vent pipes and all other pipes when above ground shall be approved gastight by a smoke test conducted under a pressure of 25 mm of water and maintained for 15 minutes after all trap seals have been filled with water. The smoke is produced by burning oily waste or tarpaper or similar material in the combustion chamber of a smoke machine. Chemical smokes shall not be used.

b) Water test

The pipes shall be subjected to a test pressure of at least 1.5 m head of water at the highest point of the section under tests. The tolerance figure of two litres per centimetre of diameter per kilometre may be allowed during a period of 10 (ten) minutes. The test shall be carried out by suitably plugging the low end of the drain and the ends of connections, if any, and filling the system, with water. A knuckle bend shall be temporarily jointed in at the top end and a sufficient length of the vertical pipe jointed to it so as to provide the required test head or the top end may be plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained and fixed suitably for observation.

Subsidence of test water may be due to one or more of the following cases:

a) Absorption by pipes and joints

b) Sweating of pipes or joints

c) Leakage at joints or from defective pipes

d) Trapped air.

Allowance shall be made for (a) by adding water until absorption has ceased and after which the test proper should commence. Any leakage and the defective part of the work shall be cut out and made good.

c) For straightness

i) By inserting at the high end of the sewer or drain a smooth ball of a diameter 13 mm less than the pipe bore. In the absence of obstruction, such as yarn or mortar projecting through the joints, the ball with roll down the invert of the pipe end emerge at the lower end; and

ii) By means of a mirror at one end of the line and lamp at the other. If the pipeline is straight, the full circle of light may be observed. The mirror will also indicate obstruction in the barrel if the pipeline is not straight.

4.04.00 Fittings and Fixtures etc.

All fittings and fixtures shall be connected by water tight joints. No dripping of water shall be acceptable.

4.05.00 Testing Septic Tank

The septic tank shall be tested for water tightness. It shall be filled up with water and allowed to soak for 24 hours. Then, it shall be topped up and allowed to stand again for 24 hours and loss of level recorded. The fall shall not be more than 15 mm in 24 hrs.

5.00.00 I.S. CODES

Important relevant IS Codes for this specification are listed below:

Latest editions shall always be consulted.

IS: 404	:	Lead pipes.
IS: 407	:	Brass tubes for general purposes.
IS: 458	:	Concrete pipes (with or without reinforcement)
IS: 783	:	Code of Practice for laying of concrete pipes.
IS: 1172	:	Code of basic requirements for water supply, drainage and sanitation.
IS: 1200 (Pt. XVI)	:	Laying of water and sewer lines, including appurtenant items.

IS: 1230	:	Cast iron rain water pipes and fittings.
IS: 1239 (Pt. I & III)	:	Specification for Mild Steel Tubes and Mild Steel Tubulars and other wrought steel pipe fittings (10 mm to 15 mm nominal diameter).
IS: 1536	:	Specification for centrifugally cast (Spun) iron pressure pipes for water gas and sewage.
IS: 1537	:	Specification for vertically cast iron pressure pipes for water, gas and sewage.
IS: 1592	:	Asbestos cement pressure pipes,
IS: 1626	:	Asbestos cement pressure pipes, gutters and fittings (Spigot and Socket types).
IS: 2065	:	Code of Practice for Water Supply in buildings.
IS: 2501	:	Copper tubes for general engineering purposes.
IS: 2556	:	Specification for vitreous sanitary appliances (vitreous china) Part – I - General requirement
IS: 2633	:	Method of testing, uniformity of coating on zinc coated articles.
IS: 3076	:	Low density polyethylene pipes for portable water supplies.
IS: 3486	:	Specification for Cast iron spigot and socket drain pipes (80 mm to 250 mm nominal diameter).
IS: 3589	:	Specification for Electrically welded steel pipe for water, gas and sewage (200 mm to 2000 mm nominal diameter).
IS: 4827	:	Specification for electro plated coatings of nickel and chromium on copper and copper alloy.
IS: 4964	:	High-density polyethylene pipes for portable water supplies.
IS: 12701	:	Rotational moulded polyethylene water storage tanks

6.00.00 RATE AND MEASUREMENT

6.01.00 RATE

6.01.01 G.I. Pipes for Water Supply

Rate shall include providing and fixing of the pipes including all specials and fittings, such as tees, bands, elbows, clamps, drain heads, cleanouts etc. with cutting, making chases and jointing of pipes, making good the walls.

6.01.02 Rainwater Down-comers

Rate shall include providing and fixing of the pipes including all specials and fittings, such as tees, bands, elbows, clamps, drain heads, cleanouts etc. The rate also includes cost of jointing and making good the opening in structure.

6.01.03 Sanitary Fixtures

Rate shall include providing and fixing of sanitary appliances & fixtures and at all elevation, including all accessories and fittings, connections pipes, waste trap and pipes all complete as per description of “Schedule of Items”. Rate shall also include the jointing of waste & traps to drain pipes.

6.01.04 Drainage and Sewer Pipes

Rate shall be inclusive of providing, laying and jointing of pipes as specified. Rate also include cost of lead joints or other joint as specified, cost for painting and cutting and making good walls, floors etc.

6.01.05 Floor and Gully Traps

Rate of traps is inclusive of all excavation, filling, repair, making good of opening in floor and walls, grating, painting etc. complete as described in “Schedule of Items”.

6.01.06 Manholes, Septic Tank, Soak Pit and Cover

Rate of manholes, septic tank, soak pit shall be paid under respective items of work executed like brick work, plastering, concrete, reinforcement steel etc. provided for completion of the structure as per drawing and specifications. Manhole cover shall be paid separately as per description of item.

6.01.07 Water Storage Tank

The rate for water storage tank is inclusive of supply and installation of tank with all fittings, inlets, outlets, valves etc. complete.

6.02.00 MEASUREMENTS

6.02.01 Pipe for Water Supply and Drainage

For G.I. Pipe of water supply line, rainwater down comers, drainage and sewer pipe, the measurements shall be in running metres and shall be taken along centre line of pipe or specials.

The pipe shall be measured separately according to dia. and class of pipe.

Fixtures like bibcock, stopcocks, valves etc. shall be measured in numbers.

6.02.02 Sanitary Appliances & Fixtures and Allied Works

All sanitary appliances & fixtures like sink, washbasin, WC, shall be measured in numbers for the complete work as described in schedule of items.

Floor and gully traps shall be measured in numbers unless otherwise specified.

Water storage tank shall be measured in numbers for the capacity as specified in “Schedule of Items”.

The item of work executed for completion of manholes, septic tank & soak pit shall be measured in respective items of work like brick work, RCC, plastering etc. CI cover shall be measured in numbers as specified in “Schedule of Items”.

VOLUME: II B

SECTION - D

SUB-SECTION – D16

SPECIFICATION NO. PE-TS-999-600-C016

ROAD AND DRAINAGE

Maharatna Company

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
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2.00.0	CODES AND STANDARDS	4
3.00.0	EXECUTION	7
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Standard Technical Specification
For Road and Drainage

1.00.00 Scope

The scope include all works required for the construction of road including construction of embankment, sub-base course, base course, tack coat, bituminous macadam, wearing course, liquid seal coat, shoulder and all incidental items of work specified or not shown but reasonably implied or necessary for the completion of the work etc.

The scope also include all works required for the construction of drainage including construction of road side drains, RCC culverts, pipe culverts, drainage pipes, manholes and all other incidental items necessary for the completion of the work etc.

1.01.00 Works to Be Provided by The Contractor

The works to be provided by the contractor unless specified otherwise shall include but not be limited to the following.

a) Construction of roads including providing all materials, labour, supervision, services, equipments, tools and plants, transportation etc. all required for the completion of the work.

b) Submission of detailed scheme of all operations required for executing the work (e.g. material handling, placement, services, approaches etc.) to the engineer for approval.

c) Carrying out tests whenever required by the engineer to assess the quality of work and submission of the test results to the engineer after completion of the same etc.

1.02.00 Work to Be Provided by Others

No work under this specification will be provided for by any agency other than the contractor unless specifically mentioned elsewhere in the contract.

1.03.00 Conformity with Designs

The contractor shall carryout the work as per the construction drawings, specification and as directed by the engineer.

1.04.00 Materials to Be Used

All materials required for the work shall be the best commercial variety and as approved by the engineer.

2.00.00 Codes and Standards

All works under this specification shall conform to the latest revision and/or replacement of the following or any other IRC/IS Codes and Standard Practices unless specified otherwise.

a) Specification for road and bridge works of Ministry of Shipping & Transport (Road Wing) Published by the IRC

b) IRC: 19 - Standard specification and code of practice for Water bound Macadam

c) IRC: SP 11 - Hand Book of Quality Control for Construction of Roads and Runways

d) IS:456 - Indian Standard Code of Practice for Plain and Reinforced Concrete.

e) IS:2212 - Code of Practice for Brick work

f) IS: 783 - Code of Practice for Laying of Concrete Pipes

g) IS: 1201 - Methods of testing tar and bituminous materials to 1220

h) IS: 73 - Specification for paving bitumen

i) IS: 215 - Specification for Road tar

j) IS: 216 - Coal tar pitch

k) IS: 217 - Specification for cut-back bitumen

l) IS: 454 - Specification for cut-back bitumen from waxy crude

m) IS: 1834 - Specification for hot applied sealing compound for joint in concrete

n) IS: 1838 - Specification for performed fillers for expansion joints in concrete, non-extruding and resilient type
Part I Bitumen impregnated fibre

Part II CNSL Aldehyde resin and coconut pith

o) IS: 334 - Glossary of terms relating to bitumen and tar

p) IS: 1077 - Common burnt clay building bricks

q) IS: 3117 - Specification for bitumen emulsion roads (anionic type)

r) IS: 1200 - Method of measurement of building and civil engineering work (Part-17)- Road work including airfield pavements

s) Other specifications mentioned elsewhere in this specification.

In case any particular aspect of work is not covered specifically by the specification/Indian Standard Code of practices, any other standard practice as may be specified by the engineer shall be followed.

2.01.00 Quality Control

The Contractor shall establish and maintain quality control for all materials, procedures, workmanship and equipments used. All works shall conform to the lines, grades, cross sections and dimensions shown on the drawings, specification and as directed by the engineer. Permitted tolerances for road works are described hereinafter.

a) Horizontal Alignment

Horizontal alignment shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of ± 25mm therefrom. The corresponding tolerance for edges of the roadway and lower layers of the pavement shall be ± 40mm.

b) Longitudinal Profile

The finished levels of the sub-grade and different pavement courses as constructed shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the engineer and shall not exceed the tolerances as mentioned below.

Sub-grade ± 25 mm
Sub-base ± 20 mm
Base course ± 15 mm
Wearing course ± 10 mm

Tolerance in wearing course shall not be permitted in conjunction with the positive tolerance on base course if the thickness of the wearing course is thereby reduced by more than 6 mm.

c) Surface Regularity of Sub-grade and Pavement Courses

The surface regularity of the completed sub-base, base course and wearing surfaces in the longitudinal and transverse directions shall be within the tolerances indicated in Table - I. The longitudinal profile shall be checked with a 3m long straight edge at the middle of each traffic lane along a line parallel to the center of the road. The transverse profile shall be checked with a set of three camber boards at intervals of 10m.

TABLE –I

PERMITTED TOLERANCE OF SURFACE REGULARITY FOR PAVEMENT COURSES

Sl. No.	Type of Construction	Longitudinal profile with 3m straight edge					Cross Profile
		Maximum permissible Undulation (mm)	Maximum number of undulations permitted in any 300m length with undulation exceeding (mm)				Maximum permissible variation from specified profile under camber template (mm)
			18	12	10	6	
1	2	3	4	5	6	7	8
1.	Earthen sub-grade	25	30	-	-	-	15
2.	Granular sub-base	15	-	30	-	-	12
3.	Water Bound Macadam with oversize metal (40-90 mm size)	15	-	30	-	-	12
4.	Water Bound Macadam with normal size metal (20-50 mm and 40-63 mm size), Bituminous Penetration Macadam	12	-	-	30	-	8

5.	Surface dressing** (two coat) over WBM (20-50 mm or 40-63 mm size metal), Bituminous penetration macadam	12	-	-	20	-	8
6.	Open graded premix carpet, mix seal Surfacing	10	-	-	-	30	6
7.	Bituminous macadam	10	-	-	-	20***	6
8.	Semi-dense carpet	10	-	-	-	20***	6
9.	Asphaltic Concrete	8	-	-	-	10***	4

Notes:

1. ** For surface dressing in all other cases, the standards of surface evenness will be the same as those for the surface receiving the surface dressing.

2. *** These are for machine laid surfaces. If laid manually due to unavoidable reasons, tolerance upto 50 percent above these values in this column may be permitted at the discretion of the Engineer. However, this relaxation does not apply to the values of maximum undulation for longitudinal and cross profiles mentioned in columns 3 and 8 on the table.

3. Surface evenness requirements in respect of both the longitudinal and cross profiles should be simultaneously satisfied.

3.00.00 Execution

3.01.00 Setting Out

Within 15 days of the award of contract, the contractor shall prepare and submit to the Engineer detailed drawings/schemes of embankment filling and excavation works as proposed to be executed by him showing the dimensions as per construction drawings and specification adding his proposals of drainage and dewatering of pits, watering and compacting the embankment fill etc. On receiving the approval from the Engineer with modifications and corrections if any, the contractor shall set out the work from the control points furnished by the Engineer and fix permanent points and markers for ease of future checking. These permanent points and markers will be checked by the Engineer and certified by him after which the contractor shall proceed with the work. It should be noted that this checking by the Engineer prior to the start of the work will in no way absolve the contractor of his responsibility of carrying out the work to true lines and levels as per the approved drawings. If any errors are noticed in the Contractor's work at any stage, the contractor at his own risk and cost shall rectify the same. Profiles of the embankment made with Bamboo, earth or other convenient materials and strings shall be set up at suitable intervals for the guidance of the workmen.

3.02.00 Clearing and Grubbing

Before commencement of earthwork, the surface area of ground to be occupied shall be cleared of all fences, trees, logs, stumps, bushes, vegetation, rubbish, slush etc. Cutting of trees shall include trees having girth of any size and removing roots upto a depth of 600mm below ground level or 300mm below formation level whichever is deeper. After the removal of roots of trees, the pot holes formed shall be filled with good earth in 250mm layers (loose thickness) and compacted unless otherwise directed by the Engineer. The trees shall be cut into suitable pieces as instructed by the Engineer. Before earthwork is started, all the spoils and unserviceable materials and rubbish shall be burnt or removed from the site to the approved disposal areas as may be specified. Useful materials, saleable timbers, firewood etc. shall be the property of the Owner and shall be stacked properly at the work site in a manner as directed by the Engineer.

3.03.00 Filling in Embankment

3.03.01 General

The material used for constructing the embankment shall be earth, moorum, gravel or a mixture of the above or any other material approved by the Engineer. The material shall be free from lumps and clods, boulders and rock pieces, roots and vegetation, harmful salts and chemicals, organic materials, loose silts, fine sands and expansive clays in order to provide a stable embankment. The filling and compaction operation should be such that the best available materials are saved for the top portion and will result in an acceptable and uniform gradation of material and provide impermeability and stability to the embankment when compacted. The size of the coarse material in the mixture of earth shall ordinarily not exceed 75mm. However, the Engineer may at his discretion permit the use of material coarser than the specified if he is satisfied that the same will not present any difficulty as regard to the placement and compaction of the fill material are concerned. Ordinarily, only the materials satisfying the density requirements as given below in Table-II shall be employed for embankment construction.

Table - II

Density Requirements of Embankment Materials

Sl. No.	Type of Work	Maximum laboratory dry density when tested as per IS: 2720 (Part - VII)
1.	Embankment upto 3m height	Not less than 1.44 gm/cc
2.	Embankment exceeding 3m height and embankment of any height subject to long period of inundation	Not less than 1.52 gm/cc
3.	Top 0.5m of the embankment below sub-base and shoulders (where earth shoulders are specified)	Not less than 1.65 gm/cc

Expansive clays exhibiting marked swell and shrinkage properties shall not be used for embankment construction.

The material for embankment construction shall be obtained from approved sources with preference given to the materials available from nearby road excavation or any other excavation under the same contract.

3.03.02 Setting Out

After the site clearance, the work shall be set out true to lines, curves, slopes, grades and sections as shown on the approved drawings or as directed by the Engineer. The contractor shall provide all labour, survey instruments and materials such as strings, pegs, nails, bamboo, stones, lime, mortar, concrete etc. required in connection with the setting out of the works and establishment of the bench marks. The limits of the embankment shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. To ensure the safety, the pegs should normally be fixed about 500mm away from the actual limits of the fill and to be painted in a distinct colour. The centreline of the embankment shall be pegged at regular intervals of 25/30m and at all skews/curves. The actual profile of the embankment shall be made at every third centre line peg with bamboo posts and strings. Preferably prototype profiles developed with wooden planks need to be fixed at every 200m and at the intersection points at curves. The profile shall be about 3m long.

3.03.03 Stripping and Storing top soil

The construction of the earthen embankment by filling shall conform to the dimensions, slopes and other details shown in the approved drawings. Before commencement of the embankment construction, the surface area of ground to be occupied after clearing and grubbing shall be stripped off to a minimum depth of 150mm or more as directed by the Engineer in order to remove all perishable materials and any soil which may become unstable on saturation or may interfere with the development or proper bonding between the foundation and embankment. It is not necessary to remove all the soil containing fine hair like roots but only the rather heavy mats are to be removed. In localities where most of the available embankment fill materials are not conducive to plant growth or when so directed by the Engineer, the top soil suitable for plant growth existing over the embankment foundation areas shall be stripped to specified depths not exceeding 150mm and stored for covering the embankment slopes where revegetation is desired.

3.03.04 Compacting Original Ground

In all cases, the original ground after stripping shall be compacted by rolling with a minimum six passes of 8-10 tons' roller and as directed by the Engineer.

Where the height of the proposed embankment is less than 0.5m and the original ground does not already have a relative compaction of atleast 95 percent of Standard Proctor density (maximum dry density), the same shall be loosened upto a depth of 0.5m and filled in layers not exceeding 250mm in loose thickness and each layer shall be watered and compacted to 100% maximum dry density of the fill material determined in accordance with IS:2720, Part-VII. However before relaying and compacting the loosened material, the surface below this level shall be suitably compacted as directed by the Engineer with a minimum six passes of 8 - 10 tonne roller.

Where so directed by the Engineer, any unsuitable material occurring in the embankment foundation shall be removed and replaced with approved materials suitably compacted. Embankment work shall not proceed until the foundation soil of the embankment is inspected by the Engineer and approved.

3.03.05 Filling

The embankment material shall be spread uniformly over the entire width of the embankment in layers not exceeding 250mm in loose thickness. Successive layers of embankment shall not be placed until the layer under construction has been thoroughly compacted to the requirements set down hereunder. Moisture content of the fill material shall be checked at the source of supply and if found less than that specified for compaction, the same shall

be made good either at the source or after spreading the soil in loose thickness for compaction. In the latter case water shall be sprinkled directly from a hose line or from a truck mounted water tank and flooding shall not be permitted under any circumstances. After adding required amount of water, the soil shall be processed by means of harrows, rotary mixers or by any other approved method until the layer is uniformly wet.

If the material delivered to the road bed is too wet, it shall be dried by aeration and exposure to the sun till the moisture content is acceptable for compaction. Should circumstances arise where owing to wet weather, the moisture content cannot be reduced to the required amount by the above procedure, the work on compaction shall be suspended.

Moisture content of each layer shall be checked in accordance with IS:2720, Part-II and unless otherwise specified shall be so maintained making due allowance for evaporation losses that during compaction, the moisture content shall be in the range of 1 percent above to 2 percent below the optimum moisture content as determined in accordance with IS:2720, Part-VII.

Clods or hard lumps of earth shall be broken to have a maximum size of 150mm when being placed in the lower layers of the embankment and a maximum size of 60mm when being placed in the top 0.5m portion of the embankment below sub-base.

Hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer to minimise rutting or uneven compaction.

Where the embankment is to be constructed across a low swampy ground that will not support the weight of trucks or other hauling equipments, the lower part of the fill shall be constructed by dumping successive loads in a uniformly distributed layer to a thickness not greater than that necessary to support the hauling equipment while placing subsequent layers.

3.03.06 Compaction

Compaction equipment approved by the Engineer shall only be employed for construction. If directed by the Engineer, the Contractor shall demonstrate the efficiency of the plant he intends to use by carrying out compaction trials.
Each layer shall be thoroughly compacted to the density as specified in Table-III. Subsequent layers shall be placed only after the finished layer has been tested and accepted by the Engineer.

Table - III

Compaction Requirements for Embankment

Sl. No.	Type of work/material	Field dry density as a percentage of maximum laboratory dry density as per IS: 2720, Part-VII
1.	Top 0.5m portion of embankment below sub-base and shoulders	Not less than 100
2.	Other portions of embankment	Not less than 95

When density measurements reveal any soft area in the embankment, further compaction shall be carried out as directed by the Engineer. If in spite of that the specified compaction is not achieved, the material in the soft area shall be removed and replaced with approved material and compacted to the density requirements and satisfaction of the Engineer.

3.03.07 Drainage

The surface of the embankment at all times during construction shall be maintained at such a cross fall as will shed water and prevent ponding.

3.03.08 Finishing Operations

Finishing operations shall include the work of shaping and dressing the shoulders, road bed and side slopes to conform the alignment, levels, cross sections and dimensions as shown on the drawings or as directed by the Engineer. Both the upper and lower ends of the side slopes shall be rounded off to improve the appearance and merge the embankment with the adjacent terrain.

3.04.00 Turfing with Sods

3.04.01 General

This work shall consist of furnishing and laying live sod of perennial turf forming grass on embankment slopes, shoulders or other locations as shown on the drawings or as directed by the Engineer. Unless otherwise specified the work shall be taken up following the construction of embankment provided the season is favourable for establishment of the sod.

3.04.02 Materials

The sod shall consist of dense, well rooted growth of permanent and desirable grasses indigenous to the locality where it is to be used and shall be practically

free from weeds and other undesirable matters. At the time the sod is cut, the grass shall have a length of approximately 50mm and the sod shall be free from any debris.

Thickness of the sod shall be as uniform as possible with about 50 to 80mm of soil covering the grass roots depending on the nature of the sod so that practically all the dense root system of the grass is retained in the sod strip. The sods shall be cut in rectangular strips of uniform width not less than 250mm x 300mm in size but not so large so that it is convenient to handle and transport without damage. During wet weather the sod shall be allowed to dry sufficiently to prevent rearing during handling and during dry weather it shall be watered before lifting to ensure its vitality and to prevent dropping of soil during handling.

3.04.03 Placing The Sods

The area to be sodded shall be previously constructed to the required slope and cross section. Soil in the area shall be loosened, freed from all stones larger than 50mm size, sticks, stumps and any other undesirable foreign matters etc. and brought to a reasonably granular texture to a depth not less than 25mm for receiving the sod.

Where required, top soil shall be spread over the slopes. Prior to placing the top soil, the slopes shall be roughened and wetted in order to have a satisfactory bond. The depth of top soil (to be spread) shall be 75mm.

Following soil preparation and top soiling (if required), fertilizer and ground limestone when specified shall be spread uniformly. After spreading, the materials shall be incorporated in the soil by discing or other means. The prepared sod bed shall be moistened if not already sufficiently moist and the sod shall be placed thereon within 24 hours after the same has been cut. Each sod strip shall be laid in close contact with each other and shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil. At points where water may flow over the sod, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth shall be placed over it followed by thorough compaction.

3.04.04 Staking the Sods

Where the side slope is 2 to 1 or steeper and the distance along the slope is more than 2m, the sods shall be staked with pegs or nails spaced approximately 500 to 1000mm along the longitudinal axis of the sod strips. Stakes shall be driven approximately plumb through the sods and to be almost flushed with them.

3.04.05 Top Dressing

After the sods have been laid in position, the surface shall be cleaned of any loose sod, excess soil and other foreign materials. Thereafter a thin layer of top soil shall be scattered over the top dressed surface and the area shall be thoroughly moistened by sprinkling water.

3.04.06 Watering and Maintenance

The turfing so laid shall be well watered and protected until final acceptance. Watering shall be done in such a way that no erosion or damage to the sodded areas/embankment occur. The Contractor shall erect necessary warning signs and barriers, repair or replace the sods which are failing to show uniform growth of grass or damaged by his operation and shall maintain the sod at his own cost until final acceptance.

3.05.00 Shoulder Construction

3.05.01 Description

This work shall consist of constructing shoulder on either side of the pavement in accordance with the requirements of this specification and in conformity with the lines, grades and cross sections shown on the approved drawings and as directed by the Engineer.

3.05.02 Materials

Shoulder shall be made of selected earth or granular material as specified conforming to relevant IRC standards.

3.05.03 Construction Operations

Except in the case of bituminous pavements, the shoulders shall be constructed in advance to the laying of pavement courses. The compacted thickness of each layer of shoulder shall correspond to the compacted layer of pavement course to be laid adjacent to it. After compaction, the inside edges of shoulders shall be trimmed vertical and the area enclosed between the shoulders shall be cleaned of all spilled materials before proceeding with the construction of the pavement layer.

In the case of bituminous pavements, shoulder shall be constructed only after the pavement courses have been laid and compacted.

Regardless of the method of laying, all shoulder construction material shall be placed directly on the shoulder. Any spilled material dragged on to the pavement surface shall be immediately removed without any damage to the

pavement and the area so affected shall be thoroughly cleaned. During all stages of shoulder construction, the required cross fall shall be maintained to drain off surface water.

3.06.00 Kerb

3.06.01 Material

Kerb if required for the construction of footpath shall consist of precast concrete blocks with concrete grade of M-20. The blocks shall be of 100mm thick and of suitable length. The depth of blocks unless otherwise mentioned elsewhere shall be 375mm considering 225mm height of footpath above the road level.

3.06.02 Laying

The kerb shall be laid by cutting trenches of 150mm deep. The width of the trench shall be minimum and just sufficient to insert the kerbs. The inside faces of the kerbs shall be in plumb and the gap between the block shall not be more than 10mm.The gap shall be filled with cement mortar as specified.

The kerbs shall be thoroughly packed with a mixture of stone chips (50%) and moorum (50%) at the outside face. The laying and packing shall be done in a proper workmanlike manner acceptable to the Engineer.

3.07.00 Sub-base (Granular Sub-base)

3.07.01 Description

This work shall consist of laying and compacting well graded material on the prepared sub-grade in accordance with the specification. The material shall be laid in one or more layers as shown on the drawings and shall conform to the lines, grades and cross sections shown on the drawings and as directed by the Engineer.

3.07.02 Materials

The materials to be used for the work shall be natural sand, moorum, gravel, crushed stone, crushed slag, crushed concrete, brick metal, laterite, kankar etc or combinations thereof depending upon the grading required. The mixed materials shall be free from organic and other deleterious constituents and conform to one of the three grading given in Table - IV below.

Table - IV
Grading for Granular Sub-Base Material

Sieve designation	Percent by weight passing the sieve		
	Grading 1	Grading 2	Grading 3
80 mm 63 mm 4.75 mm 75 micron	100 90 - 100 35 - 70 0 - 20	100 90 - 100 40 - 90 0 - 25	100 90 - 100 50 - 100 0 - 30
Minimum CBR value for the fraction of material passing 20 mm sieve.	30 %	25%	20%

Note: The materials passing 425micron sieve for all the three gradings when tested according to IS: 2720, Part V shall have liquid limit and plasticity index not more than 25 percent and 6 percent respectively.

3.07.03 Physical Requirements

The fraction of materials passing 20mm sieve shall give a CBR value as specified in Table – IV when tested in accordance with IS: 2720, Part XVI after preparing the samples at maximum dry density and optimum moisture content corresponding to IS: 2720, Part VII and soaking the same in water for 4 days.

3.07.04 Spreading and Compacting

Immediately prior to laying of sub-base, the sub-grade already finished shall be prepared by removing all vegetation's and other extraneous matters, lightly sprinkled with water if necessary and rolled with one pass of 8 - 10 tonne smooth wheeled roller.

The sub-base material shall be spread on the sub-grade with the help of a drag spreader, motor grader or other approved means. The thickness of loose layers shall be so regulated that the maximum thickness of each layer after compaction shall not exceed 150mm.

Moisture content of the loose material shall be checked in accordance with IS: 2720, Part II and shall be suitably adjusted by sprinkling additional water from a hose line, truck mounted water tank or other approved means so that at the time of compaction it shall be from 1 percent above to 2 percent below the optimum moisture content. While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means if so directed by the Engineer until the layer is uniformly wet.

Immediately thereafter, rolling shall be done with 8 to 10 tonne smooth wheeled rollers or with any other approved plant. Rolling shall commence from the edges and progress towards the centre longitudinally except on super elevated portions where it shall progress from the lower to the upper edge parallel to the centre line of the pavement. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. During rolling, the grade and camber shall be checked and any high spots or depressions which become apparent shall be corrected by removing or adding fresh material.

Rolling shall be continued till the density achieved is at least 100% of the maximum dry density of the material determined as per IS: 2720, Part VII. The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction plant and from compaction planes, ridges, cracks or loose materials. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and recompacted.

3.08.00 Water Bound Macadam Sub-base/Base Course

3.08.01 Description

Water bound macadam shall consist of clean crushed aggregates mechanically interlocked by rolling and bonded together with screenings, binding material wherever necessary and water, laid on the prepared sub-grade or sub-base as the case may be and finished in accordance with the specification and in conformity with the lines, grades and cross-sections shown on the approved drawings.

3.08.02 Materials

a) Coarse Aggregates - General Requirements

Coarse aggregates shall be either crushed or broken stone. The aggregates shall conform to the physical requirements set forth in Table - V.

Table – V

Physical Requirements of Coarse Aggregates for Water Bound Macadam

S.No.	Type of Construction	Test	**Test method**	Requirements
1.	Sub-base	Los Angeles Abrasion Value *	IS: 2386 (Part IV)	50 percent maximum
		or		
		Aggregate Impact Value	IS: 2386 (Part IV) or IS: 5640**	40 percent maximum
2.	Base	a) Loss Angeles Abrasion value*	IS: 2386 (Part IV)	50 percent maximum
		or		
		Aggregate Impact Value	IS: 2386 (Part IV) or IS: 5640 **	40 percent maximum
		b) Flakiness Index ***	IS: 2386 (Part I)	15 percent maximum

* Aggregates shall satisfy requirements of either of the two tests.

** Aggregates like brick metal, kankar and laterite which get softened in presence of water shall be tested for impact value under conditions in accordance with IS: 5640.

*** The requirements of Flakiness Index shall be enforced only in case of crushed or broken stone and crushed slag.

b) Crushed or Broken Stone

Crushed or broken stone shall be hard, durable and free from excess flat, elongated, soft and disintegrated particles, dirt and other objectionable matters.

c) Grading Requirements of Coarse Aggregates

The coarse aggregates shall conform to one of the gradings given in Table – VI. However, the use of Grading-1 shall be restricted to sub-base courses only.

Table - VI
Grading Requirements of Coarse Aggregates

Grading	Size range	Sieve designation	Percent by weight passing the sieve
1.	90mm to 40 mm	100 mm 80 mm 63 mm 40 mm 20 mm	100 65 - 85 25 - 60 0 - 15 0 - 5
2.	63 mm to 40 mm	80 mm 63 mm 50 mm 40 mm 20 mm	100 90 - 100 35 - 70 0 - 15 0 - 5
3.	50 mm to 20 mm	63 mm 50 mm 40 mm 20 mm 10 mm	100 95 - 100 35 - 70 0 - 10 0 - 5

d) Screenings

Screenings to fill the voids in the coarse aggregate shall generally consist of the same material as the coarse aggregates. However, where permitted, predominantly non-plastic material such as moorum or gravel (other than rounded river borne material) may be used for this purpose provided liquid limit and plasticity index of such material is below 20 and 6 respectively and fraction passing 75-micron sieve does not exceed 10 percent.

As far as possible, screenings shall conform to the grading set forth in Table-VII. Screenings of Type-A in Table-VII shall be used with coarse aggregates of Grading-1 in Table-VI. Screenings of Type-A or B shall be used with coarse aggregates of Grading-2. Screenings of Type-B shall be used with coarse aggregates of Grading-3.

Table - VII
Grading for Screenings

Grading classification	Size of screenings	Sieve designation	Percent by weight passing the sieve
A	12.5 mm	12.5 mm 10.0 mm 4.75 mm 150 micron	100 90 - 100 10 - 30 0 - 8
B	10 mm	10 mm 4.75 mm 150 micron	100 85 - 100 10 - 30

e) Binding Material

Binding material to be used for water bound macadam construction shall comprise of a suitable material approved by the Engineer having plasticity index value less than 6 as determined in accordance with IS: 2720, Part V. Application of binding material may not be necessary when the screenings used are of crushable type such as moorum or gravel.

3.08.03 Construction Operations

a) The sub-grade/sub-base to receive the water bound macadam coarse shall be prepared to the specified grade and camber and made free of any dust and other extraneous materials. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm. Where water bound macadam is to be laid over an existing black topped surface, 50mm x 50mm furrows shall be cut at an angle of 45 degrees to the center line of the road at 1m intervals in the latter before laying the coarse aggregates.

b) Inverted Choke

If water bound macadam is to be laid directly over the sub-grade without any other intervening pavement course, a 25mm course of screenings (Grading-B) shall be spread on the prepared sub-grade before application of coarse aggregates is taken up.

c) Spreading Coarse Aggregates

The coarse aggregates shall be spread uniformly over the prepared surface in such quantities that the thickness of each compacted layer is limited to 100mm for Grading-1 and 75 - 100mm for Grading-2 and 3. The spreading shall be

done from stockpiles along the side of the roadway or directly from the vehicles. In no case shall the aggregate be dumped in heaps directly on the surface prepared to receive the aggregates nor shall hauling over permitted. The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregates as may be required. No segregation of large or fine particles shall be allowed and the coarse aggregates as spread shall be of uniform gradation with no pockets of fine material. The coarse aggregates shall not normally be spread more than 3 days in advance of the subsequent construction operation.

d) Rolling

Immediately following the spreading of the coarse aggregates, rolling shall be started with three wheeled power rollers of 8 to 10 tonne capacity or with tandem or vibratory rollers of approved type. The weight of the roller shall depend upon the type of the aggregate and be indicated by the Engineer.

Except on super elevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inwards parallel to the centre line of the road. Each pass of the roller shall uniformly overlap not less than one half the width of the track made in the preceding pass.

Rolling shall continue until the aggregates are thoroughly keyed and the creeping of aggregates ahead of the roller is no longer visible. During rolling slight sprinkling of water may be done if necessary. Rolling shall not be done when the sub-grade is soft or yielding or when it causes a wavelike motion in the sub-grade or sub-base course.

The rolled surface shall be checked transversely and longitudinally with templates and any irregularities found shall be corrected by loosening the surface, adding or removing necessary amount of aggregates and rerolled until the entire surface conform to the desired camber and grade. In no case shall the use of screenings be permitted to make up the depressions.

e) Application of Screenings

After the coarse aggregate has been rolled, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregates. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreader or directly from trucks. Trucks operating for spreading the screenings shall be so driven as not to disturb the coarse aggregates.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms or hand brooms or with both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregates.

The spreading, rolling and brooming of screenings shall be carried out in only such lengths of road which could be completed within one day's operation.

f) Sprinkling and Grouting

After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to seep the wet screenings into the voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued with additional screenings applied as necessary until the coarse aggregates are thoroughly keyed, well bonded and firmly set to its full depth and a grout has been formed of screenings. Care shall be taken to see that the base or sub-grade does not get damaged due to the addition of excess quantity of water during construction.

g) Application of Binding Material

After the application of screenings, the binding material where it is required to be used shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water and the resulting slurry shall be swept in with hand brooms or mechanical brooms to fill the voids properly and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling the voids form a wave ahead of the wheels of the moving roller.

h) Setting and Drying

After the final compaction of water bound macadam course, the road shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam is set. The Engineer shall have the discretion to stop hauling traffic from using the complete water bound macadam course if in his opinion it would cause excessive damage to the surface.

3.09.00 Tack Coat

3.09.01 Description

The work shall consist of application of a single coat of low viscosity liquid bituminous material to an existing road surface preparatory to another bituminous construction.

3.09.02 Materials

The binder used for tack coat shall be bitumen of a suitable grade as approved by the Engineer and conforming to IS-73, IS-217 or IS-454 as applicable or any other approved cutback.

3.09.03 Construction Operations

a) Preparation of Base

The surface on which the tack coat is to be applied shall be thoroughly swept and scraped clean of dust and any other extraneous materials before the application of the binder.

b) Application of Binder

Binder shall be heated to the temperature appropriate to the grade of bitumen used and approved by the Engineer and sprayed on the base at the rate specified below. The rate of spread in terms of straight run bitumen shall be 5 kg per 10 square metre area for an untreated water bound macadam surface. The binder shall be supplied uniformly with the aid of sprayers. The tack coat shall be applied just ahead of the oncoming bituminous construction.

3.10.00 Bituminous Macadam Binder Course

3.10.01 Description

This work shall consist of construction in a single course of 50mm/75mm thickness of compacted crushed aggregates premixed with a bituminous binder laid immediately after mixing on a base prepared previously in accordance with the specification and in conformity with the lines, grades and cross sections shown on the approved drawings.

3.10.02 Materials

a) Binder

The Binder shall be straight run bitumen of a suitable grade as directed by the Engineer complying with IS: 73.

b) Aggregates

The aggregates shall consist of crushed stone, crushed gravel (shingle) or other stones. They shall be clean, strong, durable, fairly cubical in shape and free from any disintegrated pieces, organic and other deleterious matter and adherent coats. The aggregates shall preferably be hydrophobic and of low porosity.

The aggregates shall satisfy the physical requirements set forth in Table - VIII.

Table – VIII

Physical Requirements of Aggregates for Bituminous Macadam

Sl. No.	Test	Test method	Requirements
1.	Los Angeles Abrasion Value *	IS: 2386 (Part IV)	35 percent maximum
2.	Aggregate Impact Value *	IS: 2386 (Part IV)	30 percent maximum
3.	Flakiness Index	IS: 2386 (Part I)	35 percent maximum
4.	Stripping Value	IS: 6241 (Part IV)	25 percent maximum
5.	Water Absorption	IS: 2386 (Part III)	2 percent maximum

*Aggregates may satisfy requirements of either of the two tests.

The aggregates for bituminous macadam for different thickness shall conform to Grading- A or B as given in Table-IX or X as the case may be.

Table-IX
Aggregates Grading for 75mm Compacted Thickness of Bituminous Macadam

Sieve Designation	Percent by weight passing the sieve	
	Grading A	Grading B
63 mm	100	
50 mm	90 - 100	
40 mm	35 - 65	100
25 mm	20 - 40	70 - 100
20 mm	-	50 - 80
12.5 mm	5 - 20	-
4.75 mm	-	10 - 30
2.36 mm	-	5 - 20
75 micron	0 - 5	0 - 4

Table-X
Aggregates Grading for 50mm Compacted Thickness of Bituminous Macadam

Sieve Designation	Percent by weight passing the sieve	
	Grading A	Grading B
50 mm	100	
40 mm	90 - 100	
25 mm	50 - 80	100
20 mm	-	70 -100
12.5 mm	10 - 30	-
10 mm	-	35 - 60
4.75 mm	-	15 - 35
2.36 mm	-	5 - 20
75 micron	0 - 5	0 - 4

c) Proportioning of Materials

The binder content for premixing shall be 3.5 and 4.0 percent by weight of the total mix for aggregate Grading-A and B respectively unless directed otherwise by the Engineer. The quantity of aggregates to be used shall be sufficient to yield the specified thickness after compaction.

d) Variation in Proportioning of Materials

The Contractor shall have the responsibility for ensuring proper proportion of materials and producing a uniform mix. A variation in binder content upto ± 0.3 percent by weight of total mix shall however be permissible for individual specimens taken for quality control tests.

3.10.03 Construction Operations

a) Weather and Seasonal Limitations

Bituminous macadam shall not be laid during rainy weather or when the base course is damp or wet.

b) Preparation of Base

The base on which the bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross sections as shown on the drawings and as directed by the Engineer. The surface shall be thoroughly swept and scraped clean and free of any dust and foreign matter.

c) Tack Coat

A tack coat shall be applied over the base.

d) Preparation and Transport of Mix

Hot mix plant of adequate capacity shall be used for preparing the mix. The temperature of binder at the time of mixing shall be in the range 150 Deg. - 165 Deg. C and to that of aggregates shall be in the range 125 Deg. - 150 Deg. C provided the temperature difference between the binder and the aggregate at no time exceeds 25 Deg. C. Mixing shall be thorough to ensure that a homogenous mixture is obtained in which all particles of the aggregates are coated uniformly. The mixture shall be transported from the mixing plant to the point of use in a suitable vehicle. The vehicle employed for transport shall be clean and be covered over in transit if so directed by the Engineer.

e) Spreading

After mixing, the mix shall be spread immediately by means of a self-propelled mechanical paver with suitable screeds capable of spreading, tamping and finishing the mix to the specified lines, grade and cross sections. However, in restricted locations and in narrow widths where the available plants cannot operate in the opinion of the Engineer may permit manual laying of the mix. The temperature of mix at the time of laying shall be in the range 110 Deg. - 135 Deg. C.

In multilayer construction, the longitudinal joint in one layer shall offset into the layer below by about 150mm. However, the joint in the topmost layer shall be at the centre line of the pavement.

Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the centre line of the road. All joints shall be cut vertical to the full thickness of the previously laid mix and the surface painted with hot bitumen before placing fresh material.

f) Rolling

After spreading of mix, the rolling shall be done with 8 to 10 tons' power roller or with any other approved plant. Rolling should start as soon as the materials are spread. Rolling shall be done with care to avoid any undulation in the pavement surface.

Rolling on the longitudinal joint shall be done immediately after the paving operation. After this, the rolling shall commence at the edges and progress towards the center longitudinally except on superelevated portions where it shall progress from the lower to the upper edge parallel to the center line of the pavement.

The initial or breakdown rolling shall be done as soon as it is possible to roll the mixture without cracking the surface and no mix pick up on the roller wheels. The second or intermediate rolling shall follow the break down rolling as early as possible and be done while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while the material is still workable enough for removal of roller marks.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding fresh materials. The rolling shall then be continued till the entire surface has been rolled to compaction and there is no crushing of aggregates and till all the roller marks are eliminated. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. The roller wheels shall be kept damp if necessary to avoid the bituminous material from sticking on the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose.

Rolling operation shall be completed in every respect before the temperature of the mix fall below 80 Deg. C.

Rollers shall not stand on the newly laid material as it may lead to undue deformation. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose fresh

surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

The bituminous macadam shall be provided with a final surfacing without any delay. If there is to be any delay the course shall be covered by seal coat before allowing any traffic over it.

3.11.00 Open Graded Premix Carpet

3.11.01 Description

This work shall consist of laying and compacting open graded carpet of specified thickness in a single course of suitable small sized aggregates premixed with bituminous binder on a previously prepared base to form wearing course in accordance with the specification.

3.11.02 Materials

a) Binder

The binder shall be bitumen of suitable grade as approved by the Engineer and satisfying the requirements of IS: 73, 217, 454 or any other approved cutback as applicable.

b) Aggregates

The aggregates shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be obtained by crushing rock, gravel or river shingle and be free of elongated and flaky pieces, soft and disintegrated materials, vegetable and any other deleterious matter etc. They shall preferably be hydrophobic type. The aggregates shall satisfy the quality requirements set forth in Table-VIII except that the flakiness Index shall be limited to a maximum of 30.

c) Proportioning of Materials

The materials shall be proportioned as per the quantities given in Table-XI for 20mm thick open graded premix carpet.

Table - XI

Quantity of Materials Required for 10 Sq. M of Road Surface for 20mm Thick Open Graded Premix Carpet

Aggregates for Carpet		
i)	Stone Chippings - 12mm size; passing 20 mm sieve and retained on 10 mm sieve	0.18 Cu.m
ii)	Stone Chippings - 10 mm size; passing 12.5 mm sieve and retained on 6.3 mm sieve	0.09 Cu.m
	Total	0. 27 Cu.m
Binder for premixing (quantities in terms of straight run bitumen)		
i)	For 0. 18 Cu.m of 12 mm size stone Chippings at 52 Kg per Cu.m	9.5 Kg
ii)	For 0.09 Cu. M of 10mm size stone Chippings at 56 Kg per Cu.m	5.1 Kg
	Total	14.6 Kg

3.11.03 Construction Operation

a) Weather and Seasonal Limitations

Open graded premix carpet shall not be laid during rainy weather or when the base course is damp or wet or when the atmospheric temperature in shade is 16 Deg. C or below.

b) Preparation of Base

The underlying base on which the bituminous carpet is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with the drawing, specification and as directed by the Engineer. The surface shall be well cleaned by removing caked earth and other foreign matters with wire brushes, sweeping with brooms and finally dusting with sacks as necessary.

c) Tack Coat

A tack coat complying with clause 3.09.00 shall be applied over the base preparatory to laying of the carpet. However, application of tack coat shall not be necessary when the laying of carpet follows soon after laying the bituminous course.

d) Preparation of Premix

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder. The binder shall be heated to the temperature appropriate to the grade of bitumen approved by the Engineer in boilers of suitable design avoiding local overheating and ensuring a continuous supply. The aggregates shall be dry and suitably heated to a temperature as directed by the Engineer before these are placed in the mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified. The mixing of binder with chipping shall be continued until the chippings are thoroughly coated with the binder. The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be clean and be covered over in transit if so directed.

e) Spreading and Rolling

The premixed material shall be spread on the road surface with rakes to the required thickness and camber or distributed evenly with the help of a drag spreader without any undue loss of time. The camber shall be checked by means of camber boards and inequalities evened out. As soon as sufficient length of bituminous material is laid, rolling shall be commenced with 6 to 8 tons' power rollers preferably with smooth wheel tandem type or with any other approved plant. Rolling shall begin at the edges and progress toward the center longitudinally except on the superelevated portions where it shall progress from the lower to upper edge parallel to the center line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled to compaction and all the roller marks have been eliminated. In each pass of the roller, preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose. Rollers shall not stand on newly laid material as it may lead to undue deformations.

The edges along and transverse of the carpet laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted

with a thin surface coat of approved binder before the new mix is placed against it.

f) Seal Coat

A seal coat conforming to clause 3.12.00 shall be applied to the surface immediately after laying the carpet. No traffic shall be allowed on the road till the seal coat has been placed.

3.12.00 Seal Coat

3.12.01 Description

This work shall consist of application of a seal coat as specified for sealing the voids in the bituminous surface laid to the specified levels, grade and camber.

Type-A: Liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chippings.

Type-B: Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

3.12.02 Materials

a) Binder

The binder shall be bitumen of suitable grade as directed by the Engineer and conforming to the requirements of IS: 73, 217 or 454 as applicable or any other approved cutback.

The quantity of binder to be adopted in terms of straight run bitumen shall be 9.8 Kg and 6.8 Kg per 10 square metre area for Type-A and Type-B seal coat respectively.

b) Stone Chippings for Type a Seal Coat

The stone chippings shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be free of elongated or flaky pieces, soft or disintegrated stone, vegetable or other deleterious matters etc. Stone chippings shall be of 6mm size defined as 100 percent passing through 10mm sieve and retained on 2.36mm sieve. The quantity used for spreading shall be 0.09 cu.m. per 10 sq.m area. The chippings shall satisfy the quality requirements spelled out in Table- VIII except that the upper limit for flakiness Index shall be 30.

c) Fine Aggregate for Type B Seal Coat

The fine aggregate shall be sand or fine grit and shall consist of clean, hard, durable, uncoated dry particles and shall be free from dust, soft or flaky material, organic matter or other deleterious substances. The aggregate shall pass 1.7 mm sieve and be retained on 180-micron sieve. The quantity used for premixing shall be 0.06 cubic metre per 10 square metre area.

3.12.03 Construction Operations

a) Preparation of Base

The seal coat shall be applied immediately after laying the bituminous course which is required to be sealed. Before application of seal coat, the surface shall be cleaned free of any dust or other extraneous matters.

b) Construction of Type-A Seal Coat

The binder shall be heated in boilers of suitable design to the temperature appropriate to the grade of bitumen approved by the Engineer and sprayed on the dry surface in a uniform manner preferably with the help of mechanical sprayers. Excessive deposits of binder caused by stopping or starting of the sprayer or through leakage or due to any other reason shall be suitably corrected before the stone chippings are spread.

Immediately after the application of binder, stone chippings in a dry and clean state shall be spread uniformly on the surface preferably by means of a mechanical grittier or otherwise manually so as to cover the surface completely. If necessary, the surface shall be broomed to ensure uniform spread of chippings. Immediately after the application of the cover material, the entire surface shall be rolled with a 8 - 10 tonne smooth wheeled roller. Rolling shall commence from the edges and progress towards the centre except in superelevated portions where it shall proceed from the inner edge to the outer. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. While rolling is in progress additional chippings shall be spread by hand in whatever quantities required to make up the irregularities. Rolling shall continue until all aggregate particles are firmly bedded in the binder and present a uniform closed surface.

c) Construction of Type-B Seal Coat

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder. The binder shall be heated in boilers of suitable design to the temperature appropriate to the grade of bitumen approved by the Engineer. Also the aggregates shall be dry and suitably heated to a temperature as directed by the Engineer before the same are placed in the mixer. Mixing of

binder with aggregates to the specified proportions shall be continued till the latter is thoroughly coated with the former. The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed. As soon as sufficient length has been covered with the premixed material, the surface shall be rolled with 6 - 8 tonne smooth wheeled power rollers. Rolling shall be continued till the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained.

3.12.04 Opening to Traffic

In case of Type-B Seal coat, traffic may be allowed soon after the final rolling when the premixed materials are cooled down to the surrounding temperature. However, in case of Type- A seal coat, the traffic shall not be permitted until the following day.

3.13.00 Repair of Existing Water Bound Macadam Surfaces

Pot holes or patches and ruts in the water bound macadam base or surface course which is to be surface treated shall be repaired by removing all loose materials by cutting in rectangular patches and replacing with suitable materials. The repair shall be done as under.

Pot holes, patches and ruts shall be drained of any water and cut to regular shape with vertical sides and then be filled either with i) coarse aggregates and screenings conforming to the specification for water bound macadam and compacted with rollers or other approved rammer etc. or with ii) premixed material conforming to the specification for open graded premix carpet and compacted with rollers or other approved means after painting the sides and bottom of the holes with a thin application of bitumen or a combination of both as directed by the Engineer.

3.14.00 Road Side Drains

3.14.01 Drains

The road side drains shall be made in sizes and slopes as shown on the approved drawings. The sides and bottom shall be neatly dressed after excavation. Proper connections shall be made to the culverts outside the plant area as per the drawings and instructions of the Engineer.

The excavated spoils other than that required for backfilling shall be transported and filled in low areas within the plant area or in embankments as instructed by the Engineer. The lining for drains shall be as per the drawings. Lining of drains may be of bricks or cement concrete blocks of specified grade as shown on the approved drawing or as directed by the Engineer. If shown

on approved drawing, drains shall be of R.C.C. construction with necessary slopes.

3.15.00 Culverts

Excavation in trenches for foundation of culverts and wing walls shall be done with side slopes as per the drawings and instructions of the Engineer after clearing the site etc. As described in the "Specification for Earthwork in Excavation and Backfilling", backfilling in layers with watering and compaction shall be done after the construction of foundations. The construction of culverts shall be done true to the lines and levels as shown on the drawings. The specification for Masonry and/or Plain and Reinforced Cement concrete shall be followed as applicable.

3.16.00 Pipe Culverts and Drainage Pipes

3.16.01 Materials

The drainage pipes shall be made of R.C.C and shall be either class NP-2 or NP-3 as shown on the approved drawings. Pipe culverts shall be made of reinforced concrete pipe and shall be of class NP4 or RDSO class for railways as shown in the drawing. All pipes shall meet the requirements of IS: 458 and shall be procured from approved manufacturers with collars as per manufacturer's specification. The tenderer shall specifically mention the particular manufacturer's product he proposes to use.

Cement shall be ordinary Portland Cement as per IS:269. Coarse Aggregates shall be as per IS:383. Maximum size shall not exceed one third the thickness of the pipe or 20 mm whichever is smaller. Fine aggregates for concrete shall be as per IS:383.

3.16.02 Laying of Pipes

Laying of concrete pipes shall correspond to IS:783 and as per the specification given below.

a) The foundation bed for pipe shall be excavated true to lines and grades shown on the drawings and as directed by the Engineer. When trenching is involved, its width on either side of the pipe shall not be less than 150mm and not more than one third the diameter of pipe unless otherwise instructed/permitted by the Engineer. The sides of the trench shall be as nearly vertical as possible. Side slope, shoring, bailing out water etc. as required shall be done by the Contractor.

Side slips if there be any shall be removed by the Contractor. After laying of the pipes are completed, backfilling of the trenches shall be done as per "Specification for Earthwork in Excavation and Backfilling" to the

satisfaction of the Engineer. The surplus spoils shall be transported and filled in low areas within the plant area as instructed by the Engineer.

When bedrock or boulder stratum is encountered during excavation, the excavation shall be taken down to at least 200mm below the bottom of the pipe with prior permission of the Engineer and all rock/boulders in the area shall be removed and space filled with approved earth free from stone or fragmented materials, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

Filling of trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur and shall be done as per the "Specification for Earthwork in Excavation and Backfilling". When two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm. Laying of pipes shall start from the outlet and proceed towards inlet. All pipes and fittings shall be gradually lowered into the trench or placed on the supports by approved means taking due care to avoid any damage. Under no circumstances the pipes shall be dropped into the trench or on supports from heights.

b) Pipe bedding shall be first class projection bedding for positive projecting pipes as per IS: 783 having a projection ratio not greater than 0.70. The pipe shall be carefully laid on bedding made up of fine granular materials in an earth foundation; the bedding shall be carefully shaped to fit the lower part of the pipe exterior for at least ten percent of its overall height and in which the fill material is thoroughly compacted in layers not exceeding 150mm in depth around the pipe for the remainder of the pipe laid in trench.

When indicated on the drawings or directed by the Engineer, the pipe shall be bedded on a cradle constructed of concrete having a mix not leaner than M-15. The shape and dimension of the cradle shall be as indicated on the drawing or as directed by the Engineer. The pipe shall be laid on the concrete bedding before the concrete is set.

c) The drop walls shall be made with first class brickwork in 1:4 cement mortar.

d) The pipe culverts shall be made with proper care with respect to the invert of the pipe, gradient if any etc. as specified on the drawings and as instructed by the Engineer.

e) Where R.C.C pipes are encased in concrete at road crossings or at other places the pipes need be suitably supported avoiding reinforcements of concrete blocks, joints properly done before concreting is taken up. Concreting of total height of block may be done in a single operation or may be done upto some height for pipes to be properly laid in position and the balance height of the block shall be concreted subsequently.

f) The R.C.C. pipes shall be joined with cement mortar. Cement mortar shall consist of 1 part of cement and 2 part of clean sand with only enough water for workability. Procedure of jointing shall be as per IS: 783.

3.16.03 Relation with Water Supply Pipeline

Unless specifically cleared by the Engineer, under no circumstances shall the drainage pipes be allowed to come close to water supply pipelines.

3.17.00 Manholes and Inspection Chambers

The maximum distance between the manholes shall be 30m unless specifically permitted otherwise. In addition, at every change of alignment, gradient or diameter there shall be a manhole or inspection chamber. The distance between the manhole or inspection chamber and gully chamber shall not exceed 6 meters unless permitted otherwise. Manhole shall be constructed so as to be water tight under test. The channel or drain at the bottom of chamber shall be plastered with 1:2 cement sand mortar and finished smooth to the grade. The channels and drains shall be shaped and laid to provide a smooth flow. Connection to the existing pipelines shall be through a manhole. Manholes shall be provided with standard covers usually of C.I. or as directed by the Engineer. The cover shall be closely fitted so as to prevent gases from coming out.

4.00.00 Testing and Acceptance Criteria

All testing as mentioned in the specification and as mentioned in Clause No. 900 of the "Specification for Roads and Bridge Works, 1983" published by IRC on behalf of Ministry of Shipping and Transport (Roads Wing) shall be carried out by the Contractor as per the direction of the Engineer.

5.00.00 MEASUREMENT

Method of measurement shall be as per the latest version of IS:1200, Part-17 and as directed by the Engineer.

VOLUME: II B

SECTION - D
(PART I)

SUB-SECTION – D 17

FABRICATION OF STRUCTURAL STEEL WORK

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
1.00.00	SCOPE	3
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SUB-SECTION – D XVII

FABRICATION OF STRUCTURAL STEEL WORK

1.00.00 SCOPE

This specification covers supply, fabrication, testing, painting and delivery to site of structural steelwork including supply of all consumable stores and rivets, bolts, nuts, washers, electrodes and other materials required for fabrication and field connections of all structural steelwork covered under the scope of the contract.

2.00.00 GENERAL

2.01.00 Work to be provided for by the Contractor

The work to be provided for by the Contractor, unless otherwise specified elsewhere in the contract, shall include, but not be limited to the following

a) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on the approved design drawings. As decided by the Engineer, some or all of these detailed drawings will have to be submitted for approval.

b) To submit revised design with calculations and detailed fabrication drawings in case any substitution of the designed sections are to be made.

c) To submit design calculations for joints and. connections developed by the contractor along with detailed fabrication drawings.

d) Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary rivets, bolts, nuts, washers, tie rods and welding electrodes for field connections,

e) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.

f) Suitably mark, bundle, and pack for transport all fabricated materials.

g) Prepare and furnish detailed Bill of Materials, Drawing Office Dispatch lists, Rivet and Bolt List and any other list of bought out items required in connection with the fabrication and erection of the structural steelwork.

h) Insure, load and transport all fabricated steelwork field connection materials to site.

i) Maintain a fully equipped workshop at site for fabrication, modification and repairs of steelwork at site as may be required to complete the works in accordance with the Contract.

2.02.00 Work by others

No work under this specification will be provided for by any agency other than the contractor, unless specifically mentioned otherwise elsewhere in the contract.

2.03.00 Codes and standards

All work under this specification shall, unless otherwise specified in the contract, conform to the requirements of the latest revision and/or replacements of the following or any other relevant Indian Standard specifications and codes of practice. In case any particular aspect of the work is not specifically covered by any Indian Standard specification, any other standard practice, as may be specified by the Engineer shall be followed:

IS: 226 - Structural steel (Standard Quality)

IS: 800 - Code of Practice for general construction in steel.

IS: 806 - Code of practice for use of steel tubes in general building construction.

IS: 808 - Rolled steel beams, channels, and angle sections

IS: 813 - Scheme of symbols for welding

IS: 814 - Covered electrodes for metal arc welding of structural steel

IS: 815 - Classification and coding of covered electrodes for metal arc welding of structural steels.

IS: 816 - Code of practice for use of metal arc welding for general construction in mild steel

IS: 817 - Code of practice for training and testing metal arc welders

IS: 818 - Code of practice for safety and health requirements in electric and gas welding and cutting operations

IS: 822 - Code of practice for inspection of welds

IS: 919 - Recommendations for limits and fits for Engineering

IS: 961 - Structural Steel (High Tensile)

IS: 1148 - Rivet bars for structural purposes

IS: 1149 - High tensile rivet bars for structural purposes

IS: 1161 - Steel Tubes for structural purposes

IS: 1200 - Method of measurement of steelwork and ironwork (Part 8)

IS: 1239 - Mild Steel Tubes

IS: 1363 - Black hexagon bolts, nuts and lock nuts (dia. 6 to 30 mm) and black hexagon screws (Dia 6 to 24 mm)

IS: 1364 - Precision and semi-precision hexagon bolts, screws, nuts and l locknuts (Dia, range 6 to 39 mm)

IS: 1367 - Technical supply conditions for threaded fasteners

IS: 1442 - Covered electrodes for the metal are welding of high tensile structural steel

IS: 1608 - Method for tensile testing of steel products other than sheet strip, wire and tube

IS: 1730 - Dimensions for steel plate, sheet, and strip for structural and general engineering purposes.

IS: 1731 - Dimensions for steel flats for structural and general engineering purposes

IS: 1852 - Rolling and cutting tolerances for hot-rolled steel products

IS: 1977 - Structural steel (ordinary quality) St-42-0

IS: 2062 - Steel for General Structural Purposes

IS: 2074 - Ready mixed paint, red oxide Zinc chromate priming

IS: 2595 - Code of Practice for Radiographic Testing

IS: 2629 - Recommended practice for Hot-Dip Galvanizing of Iron and Steel

IS: 2633 - Method for testing uniformity of coating on Zinc Coated Articles

IS: 3757 - High strength structural bolts

IS: 4759 - Specifications for Hot-Dip Zinc Coatings on Structural Steel and other allied products

IS: 7205 - Safety Code for Erection of Structural Steelwork

IS: 7215 - Tolerances for fabrication of steel structures

IS: 7280 - Bare wire electrodes for submerged arc welding of structural steels.

IS: 9595 - Recommendations for metal arc welding of carbon and carbon manganese steels.

2.04.00 Conformity with Designs

The contractor shall design all connections, supply and fabricate all steelwork and furnish all connection materials in accordance with the approved drawings and/or as instructed by the Engineer keeping in view the maximum Utilization of the available sizes and sections of steel materials. The methods of painting, marking, packing and delivery of all fabricated materials shall be in accordance with the provisions of the contract and/or as approved by the Engineer. Provision of all relevant Indian Standard Specifications and Codes of Practice shall be followed unless otherwise specified in the contract.

2.05.00 Materials to be used

2.05.01 General

All steel materials required for the work will be supplied by the contractor unless otherwise specified elsewhere in the contract. The materials shall be free from all imperfections, mill scales, slag intrusions, laminations, fittings, rusts etc. that may impair their strength, durability, and appearance. All materials shall be of tested quality only unless otherwise permitted by the Engineer and/or Consultant. If desired by the Engineer, Test Certificates in respect of each consignment shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks, if permitted by the Engineer, a random sample shall be tested at an approved laboratory from each lot of 50 tones or less of any particular section.

The arc welding electrodes shall be of approved reputed manufacture and conforming to the relevant Indian Standard Codes of Practice and Specifications and shall be of heavily coated type and the thickness of the coating shall be uniform and concentric. With each container of electrodes, the manufacturer shall furnish instructions giving recommended voltage and

amperage (Polarity in case of D.C. supply) for which the electrodes are suitable.

2.05.02 Steel

All steel materials to be used in construction within the purview of this specification shall comply with any of the following Indian Standard Specifications as may be applicable:

a) IS: 2062 - Steel for general structural purposes

b) IS: 961 - Structural steel High Tensile

c) IS: 1977 - Structural steel (Ordinary quality) St-42-0

In case of imported steel materials being used, these shall conform to specifications equivalent to any of the above as may be applicable.

2.05.03 Rivet Steel

All rivet steel used in construction within the purview of this Specification shall comply with one of the following Indian Standard Specifications as may be applicable:

a) IS: 1148 - Rivet Bars for structural purpose

b) IS: 1149 - High tensile rivet bars for structural purposes. Where high tensile steel is specified for rivets, steps shall be taken to ensure that the rivets are so manufactured that they can be driven and heads formed satisfactorily without the physical properties of steel being impaired.

2.05.04 Electrodes

All electrodes to be used under the Contract shall be of approved reputed manufacture, low hydrogen electrode and shall comply with any of the following Indian Standard Specifications as may be applicable

a) IS: 814 - Covered electrodes for metal arc welding of structural steel

b) IS: 815 - Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel

c) IS: 1442 - Covered electrodes for the metal arc welding of high tensile structural steel

d) IS: 7280 - Bare wire electrodes for submerged arc welding of structural steels

2.05.05 Bolts and Nuts

All bolts and nuts shall conform to the requirements of Indian Standard Specification IS: 1367 - Technical Supply Conditions for Threaded Fasteners.

Materials for Bolts and nuts under the purview of this contract shall comply with any of the following Indian Standard Specifications as may be applicable.

a) Mild Steel

All mild steel for bolts and nuts when tested in accordance with the following Indian Standard Specification shall have a tensile strength of not less than 44 Kg/mm² and a minimum elongation of 23 per cent on a gauge length of 5.6 _/A, where "A" is the cross sectional area of the test specimen

i) IS: 1367: Technical supply conditions for threaded fasteners

ii) IS: 1608: Method for tensile testing of steel products other than sheet, strip, wire and tube

b) High Tensile Steel

The material used for the manufacture of high tensile steel bolts and nuts shall have the mechanical properties appropriate to the particular class of steel as set out in IS: 1367 or as approved by the Engineer.

2.05.06 Washers

Washers shall be made of steel conforming to any of the following Indian Standard Specifications as may be applicable under the provisions of the Contract:

a) IS: 2062 - Steel for general structural purposes

b) IS: 961 - Structural Steel (High Tensile Quality)

c) IS: 1977 - Structural steel (Ordinary Quality) St-42-0

d) IS: 6649 - Hardened washers

2.05.07 Paints

Paints to be used for shop coat of fabricated steel under the purview of this contract shall conform to the Indian Standard Specification IS: 2074 - Ready Mixed Paint, Red oxide Zinc Chromate Priming.

2.06.00 Coal Bin

2.06.01 Shape of bins shall be circular, polygonal, square, or rectangular in plan. Bottom hopper portion may have been conical-cum-hyperbolic or any other profile shape as shown in the drawing. Bin shall be termed as bunkers or silos according to their shape and plane of rupture of coal.

2.06.02 For general requirements, fabrication and construction details IS: 9178 (Pt. l & 11) shall be followed as general guidance. The bins shall be fabricated and erected in segments.

2.06.03 The Coal bins shall be made of mild steel plates joined together with full strength butt weld and provided with stiffeners at regular interval. Stiffeners shall be provided on the external face and it may be welded with external face.

2.06.04 Bending of plates and rolled sections to the required shape for fabrication shall be done by plate bending machine or cold bending process Without resorting to heating, hammering, angle smithy and black smithy process.

2.06.05 Poking hole (manual or pneumatic) and striking plate shall be provided to facilitate coal flow. Poking holes shall have circular MS pipe and cover cap as detailed in the drawing.

2.07.00 New Erection Marks

2.07.01 Additional structures involving new erection marks may be required to be added at any stage of work.

2.07.02 All such new erection marks shall be detailed and included in marking schemes and fabrication carded out thereafter.

2.07.03 All such new erection marks shall be considered under item of original fabrication work. As a result of additional structures becoming necessary if the work is delayed beyond the time schedule stipulated, the Engineer shall give suitable extension of time provided he is satisfied about the reasonableness of the delay involved. However, no claim for extra payments or revision of rates due to delay shall be entertained.

2.08.00 ELECTRO FORGED STEEL GRATINGS

2.08.01 Factory made fabricated electro forged gratings unit with steel conforming to IS: 2062 shall be supplied, fabricated, transported, erected and aligned in floorings, platforms, drain and trench covers, walkways, passages, staircases with edge binding strips and anti skid nosing in treads etc.

2.08.02 All grating units shall be rectangular in pattern and electro forged. The size and the spacing of the bearing bars and cross bars shall be as detailed in fabrication drawings. The contractor shall submit the grating design for different spans and load intensities along with fabrication drawings. The depth of the grating unit shall be 40 mm, unless specified otherwise.

2.08.03 The gratings shall be made up in panel units designed to coincide with the span of the structural steel framing or openings as indicated in the design/ scope drawings. Maximum possible standardization of the grating panel sizes shall be tried and designed.

2.08.04 The grating unit shall be accurately fabricated and finished, free from wraps, twists, or any defects that would impair their strength, serviceability, and appearance.

2.08.05 Grating work shall include cut outs and clearance opening for all columns, pipes, ducts, conduits or any other installation penetrating through the grating work. Such cut outs and clearances shall be treated as specified in subsequent clauses.

2.08.06 The gratings shall be notched, trimmed and neatly finished around flanges and webs of the columns, moment connections, cap plates, and such other components of the steel structures encountered during the placement of the gratings. In all such cases, the trimming shall be done to follow the profile of the components encountered. After trimming, the binding strip shall be provided on the grating to suit the profile so obtained.

2.08.07 Opening in gratings for pipes or ducts that are 150mm in size or diameter or larger shall be provided with steel bar toe plates of not less than 5mm thickness and appropriate width, set flush with the bottom of the bearing bars.

2.08.08 Penetrations in gratings that are more than 50mm but less than 150mm in size or diameter shall be welded with plates of size shown in the detailed drawings set flush with the bottom of the grating panel.

2.08.09 Unless otherwise indicated on the drawings, grating units at all penetrations shall be made up in split section, accurately fitted and neatly finished to provide for proper assembly and erection at the job site.

2.08.10 Grating units shall be provided with all necessary clips, bolts, nuts and lock washers required for proper assembly and rigid installation and fastening to abutting units supporting structural steel framing members.

2.08.11 The gratings shall be of reputed make and manufacturer, as approved by Engineer. The unit rate quoted by him for this item shall be inclusive of transport of gratings to the project site, all taxes, duties etc. He shall also provide all facilities and access to the Engineer or his representative to carry out inspection during all stages of manufacturing of gratings.

2.08.12 Maximum deviation in linear dimension from the approved dimension shall not exceed 12mm.

2.08.13 All fabricated grating section and accessories shall be blast cleaned to near white metal surface (Sa 2½) followed by either of the following two:

(a) Two coats of red lead primer and two coats of black enamel finish paint.

(b) Hot dipped galvanization at 610 gm/sq.m.

in the shop prior to erection at site, as the approved drawing.

2.08.14 Prior to finishing all surfaces shall be cleaned, free from rust, mill scale, grease, oil, or any other foreign matter by blast cleaning. BS: 4232 shall be followed for blast cleaning.

2.08.15 Primer can be applied by spray guns or by brushes, however the finish paint shall necessarily be applied by means of spray guns. The applied coatings shall be uniform, free from voids and streaks; drilled or punched holes shall be touched up prior to erection or assembly.

2.09.00 GALVANIZATION OF GRATINGS

2.09.01 Purity of Zinc to be used-for galvanizing shall be 99.5% as per IS: 2 15

2.09.02 After the shop work is complete, the structural material shall be punched with erection mark and be hot double dip galvanized. Before galvanizing the steel section shall be thoroughly blast cleaned to near white metal surface (Sa 2½).

2.09.03 The weight of the zinc coating shall be at least 610 gm/m² - unless noted otherwise.

2.09.04 The galvanized surface shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be cleaned and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter that is loosely attached to

the steel, blistered surface, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

2.09.05 There shall be no flaking or loosening when struck squarely with a chisel faced hammer. The galvanized steel member shall withstand minimum four one minute dips in copper sulphate solution as per IS: 2633.

2.09.06 When the steel section is removed from the galvanizing kettle, excess spelter shall be removed by 'bumping'. The processes known as 'wiping' or 'scrapping' shall not be used for this purpose.

2.09.07 Defects in certain members indicating presence of impurities in the galvanizing bath in quantities larger than that permitted by the specifications or lack of quality control in any manner in the galvanizing plant, shall render the entire, production in the relevant shift liable to rejection.

2.09.08 All structural steel shall be treated with sodium dichromate or an approved equivalent solution after galvanizing; so as to prevent white storage stains.

2.09.09 If the galvanizing of any member is damaged, the Engineer shall be shown of the extent of damage, if so directed the galvanizing may have to the redone in the similar manner as stated above at no extra cost to the Owner.

2.10.00 STAINLESS STEEL HOPPERS (As per BOQ item)

2.10.01 Material

In case SS Hopper is to be fabricated & erected as per BOQ item with SS415M, following specification shall be followed.
Stainless steel hopper of grade SS 415M as manufactured by SAIL or equivalent shall be provided in the lower portion of bunker hopper. SS 4 15M having the following chemical composition shall be used.

Material	**%**	**Remarks**
Carbon	10.03%	Max.
Silicon	1.60%	Max.
Manganese	0.80% to 1.50%	
Phosphorous	0.03%	Max.
Sulphur	0.03%	Max.
Chromium	10.80% to 12.50%	

Nickel	1.50%	Max.
Titanium	0.75%	Max.
Nitrogen	0.03%	Max.

The mechanical properties shall be as follows:

Description	**Value**	**Remarks**
Hardness Rock Well B Scale	90	Max.
Tensile Strength	450 MPa	Min.
Yield Strength	300 MPa	Min.
Elongation	25%	Min.

2.10.02 Fabrication

The fabrication, erection, alignment and welding shall be carried out as per the accepted practice and in accordance with relevant I.S. and international specification as well as stipulations contained herein. Fabrication drawings shall be prepared by the contractor on the basis of the design / scope drawings furnished by Engineer. The fabrication and erection works shall be done as per the approved fabrication drawings.

2.10.03 Fabrication Drawings

a) Fabrication drawing shall give the cutting plan for each hopper plate. Such, cutting plan shall be based on the size of the Stainless Steel plate available at store. In order to reduce the wastage and ensure the maximum utilization of stainless steel plate, the cutting plan shall take in the consideration of the reverse curvature and place the various elements of hopper plate in opposite fashion to reduce the end wastage. Similarly, the hopper plate element having different radii shall be placed one inside the other, to optimize the stainless steel plate use. Such optimization may also require adjustment in the size of each element of hopper plate and also additional weld joints.

b) The bill of material of hopper plate shall indicate the inner surface area of the hopper, weight of the hopper based on the inner surface area, weight of each of the cut plate of hopper fabrication, weight of cut and scrap pieces generated. Contractor shall return to the Owner's store all unutilized (surplus) stainless steel plates and all waste and cut pieces generated. Non return of any part of the surplus/waste steel pieces to the Owner's store

will call for the penal recovery at three (03) times the maximum procurement rate for the weight of stainless steel pieces not returned to the store.

c) In case the contractor does the cutting of the stainless steel without approved cutting plan then all the wastage (i.e. the difference between the weight of stainless steel plate cuts and the actual finished weight considered for the measurement for payment) shall be subjected to the penal recovery at the rate mentioned above.

2.10.04 Cuffing

Cutting may be affected by shearing, or by using plasma. The cut edges of all plates shall be perfectly straight and uniform through out. Cutting shall be done as per the cutting plan shown in the fabrication drawing. Should the Engineer find it necessary, the edges shall be ground smooth afterwards by contractor within the unit rates quoted by him. All the edge s shall be ground smooth before they are welded.

2.10.05 Jointing

Welding shall join stainless steel. All weld joints (along the inclined plane) shall be staggered. Any common welding process can weld stainless steel viz. MIG, metal arc or plasma using the covered compatible electrodes as per IS: 5206 or by inert gas arc welding as per IS: 2811. Shielding gas shall be Argon + Hydrogen mixture or Argon + Oxygen mixture. However, Argon + Oxygen mixture shall be preferred. Carbon-di-oxide mixture shall be avoided. 308L and 315L electrodes/fillers shall be used for the welding of Stainless Steel to Stainless Steel and Stainless Steel to Mild Steel respectively. However, the welding process and the type of the electrodes to be used for welding shall be as per welding procedure, as approved by the Engineer. On the basis of the welding procedure, the Contractor shall conduct qualification test.

2.10.06 Bending

The stainless steel plates shall be subjected to cold forming and bending in order to get the desired shape and profile.

2.10.07 Welding sequence

The type of electrodes, welding sequence, preheat and interpass temperature and post weld heat treatment shall be as approved by the Engineer.

2.10.08 Acceptance Criteria of Fabricated Structures

The acceptance of the fabricated structure work shall depend upon correct dimensions and alignment, absence of distortion in the structure, satisfactory

results from the inspection and testing of the welded structure joints and the test specimens, general workmanship being good meeting the tolerance requirements given in IS: 7215.

2.11.00 BEARINGS

2.11.01 PTFE (Poly tetra fluorethylene) slide bearing

a) General

The bearings shall consist of upper and lower units. The upper unit shall include a sole plate with mirror finish stainless steel facing bonded to the bottom surface of the sole plate. The lower unit shall consist of a relevant laminated elastomers pad surfaced with PTFE. A rigid confining medium substructure bonds the PTFE to the pad. When the upper and lower units are mated the stainless steel slides on the PTFE surface with an extremely low coefficient of friction. These bearings shall be designed as per the performance requirements. The bearing shall be of reputed make and manufacturer as approved by Engineer, for required vertical loads, as per the construction drawings and for a maximum displacement of ± 50 mm.

b) Material

PTFE bearing shall be sliding against highly polished stainless steel and the coefficient of friction between them shall be less than 0.06 at 55 kg/cm². In order to prevent cold flow in the PTFE surface it shall be rigidly bonded by a special high temperature resistant adhesive to the stainless steel sub-strata. The stainless steel surface, which slides against the PTFE, is mirror polished. The stainless steel shall be bonded to the top plate by special high strength adhesive. The thickness of the stainless steel shall be between 1.0 to 1.5mm.

The resilient bearing pad shall consist of multiple layers of lightweight fabric impregnated with a high quality elastomer compound vulcanized into slabs of uniform standard thickness as per the requirement. This shall withstand vertical (compressive) load not less than 500 kg/cm² and shear loads upto 40 kg/cm².

c) Installation

The seating area for PTFE bearing shall be prepared accurately level and furnished with a thin layer of epoxy resin mortar. The bearing will be placed on this layer while it is still workable and the bearing is levelled. The bearing should not be displaced as the beam is lowered into position. When the mortar and adhesive are fully set and the beam slightly above the top of the bearing. The upper surface of the bearing shall then be coated with sufficient thickness of epoxy resin mortar so that when the

beam is lowered on to the temporary supports it comes into full contact with the mortar and some is squeezed out. The surplus shall be troweled off and after the mortar is fully set the temporary supports removed.

2.12.00 Storage of material

2.12.01 General

All materials shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for the work. Any material, which has deteriorated or has been damaged, shall be removed from the contractor's yard immediately, failing which, the Engineer shall be at liberty to get the material removed and the cost incurred thereof shall be realised from the Contractor. The Contractor shall maintain upto date accounts in respect of receipt, use, and balance of all sizes and sections of steel and other materials. In case the fabrication is carried out in contractor's fabrication shop outside the plant site where other fabrication works are also carried out, all materials meant for use in this contract shall be stacked separately with easily identifiable marks.

2.12.02 Steel

The steel to be used in fabrication and the resulting cut-pieces shall be stored in separate stacks off the ground section wise and lengthwise so that they can be easily inspected, measured, and accounted for at any time. If required by the Engineer, the materials may have to be stored under cover and suitably painted for protection against weather.

2.12.03 Electrodes

The electrodes for electric arc welding shall be stored in properly designed racks, separating different types of electrodes in distinctly marked compartments. The electrodes shall be kept in a dry and warm condition if necessary by resorting to heating.

2.12.04 Bolts, Nuts and Washers

Bolts, nuts and washers and other fastening materials shall be stored on racks off the ground with a coating of suitable protective oil. These shall be stored in separate gunny bags or compartments according to diameter, length, and quality.

2.12.05 Paints

Paints shall be stored under cover in air tight containers. Paints supplied in sealed containers shall be used up as soon as possible once the container is opened.

2.13.00 Quality Control

The Contractor shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work is performed in accordance with this specification. In addition to the Contractor's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Engineer or Engineer's representative. As far as possible, all inspection by the Engineer or Engineer's representative shall be made at the Contractor's fabrication shop whether located at Site or elsewhere. The Contractor shall co-operate with the Engineer or Engineer's representative in permitting access for inspection to all places where work is being done and in providing free of cost all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Contractor.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

The quality control procedure shall cover but not be limited to the following items of work

a) Steel: Quality manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.

b) Rivets, Bolts, Nuts & Washers : Manufacturer's certificate, dimension checks, material testing.

c) Electrodes : Manufacturer's certificate, thickness and quality of flux coating.

d) Welders : Qualifying Tests

e) Welding sets : Performance Tests

f) Welds : Inspection, X-ray, Ultrasonic tests

g) Paints : Manufacturer's certificate, physical inspection reports

h) Galvanizing : Tests in accordance with IS 2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS : 4759 - Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products.

2.14.00 Standard dimensions, forms and weights

The dimensions, forms, weights and tolerances of all rolled shapes rivets, bolts, nuts, studs, washers etc. and other members used in the fabrication of any structure shall, wherever applicable, conform to the requirements of the latest relevant Indian Standards, wherever they exist, or, in the absence of Indian Standards, to other equivalent standards.

2.15.00 Fabrication Drawings

The contractor shall within thirty (30) days after the award of the Contract submit to the Engineer the Schedule of Fabrication and erection of structural Steelworks, for approval. Within one week after receipt of approval on design of any steel structure (part or full) based on the approved design. As decided by the Engineer, six (6) copies each of some or all of the detailed fabrication drawings will have to be submitted for approval.

The sequence of preparation of fabrication drawings shall match with the approved fabrication and erection schedule. The above-mentioned approval for fabrication drawings will be accorded only towards the general conformity with the design requirements as well as specifications. The approval of drawing however shall not relieve the contractor of his sole responsibility in carrying out the work correctly and fulfilling the complete requirements of contract documents.

The fabrication drawings shall include but not limited to the following:

a) Assembly drawings giving exact sizes of the sections to be used and identification marks of the various sections.

b) Dimensional drawings of base plates, foundation bolts location etc.

c) Comparison sheets to show that the proposed alternative section, if any, is as strong as the original sections shown on the Design Drawings.

d) Complete Bill of Materials and detailed drawings of all sections as also their billing weights.

e) Any other drawings or calculations that may be required for the clarification of the works or substituted parts thereof.

These drawings shall give all the necessary information for the fabrication, erection, and painting of the steelwork in accordance with the provisions of this Specification. Fabrication drawings shall be made in accordance with the best modern practice and with due regard to sequence, speed and economy in fabrication and erection. Fabrication drawings shall give complete information

necessary for fabrication of the various components of the steelwork, including the location, type, size, and extent of welds. These shall also clearly distinguish between shop and field rivets, bolts, and welds and specify the class of bolts and nuts. The drawings shall be drawn to a scale large enough to convey all the necessary information adequately. Notes on the fabrication drawings shall indicate those joints or groups of joints in which it is particularly important that the welding sequence and technique of welding shall be carefully controlled to minimize the locked up stresses and distortion. Welding symbols used shall be in accordance with the requirements of the Indian Standard Specification. IS: 813 - Scheme of symbols for Welding, and shall be consistent throughout. Weld lengths called for on the drawings shall mean the net effective length.

The Contractor shall be responsible for and shall carry out at his cost any alterations of the work due to any discrepancies, errors or omissions on the drawings or other particulars supplied by him, whether such drawings or other particulars have been duly approved or not in accordance with the Contract.

3.00.00 WORKMANSHIP

3.01.00 Fabrication

3.01.01 General

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of the Indian Standard IS: 800 - Code of Practice for general construction in steel and other relevant Indian Standards or equivalent.

3.01.02 Straightening Material

Rolled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed by the Indian Standard Specification on IS: 1552 - Specification for rolling and cutting tolerance for hot-rolled steel products. If straightening is necessary, it may be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600°C.

3.01.03 Cutting

Shearing, cropping, or sawing shall affect cutting. Use of a mechanically controlled gas-cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under

expert hand, subject to the approval of the Engineer.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, which will be subjected to substantial stress or which are to have weld metal deposited on them, shall be reasonably free from gouges, occasional notches or gouges not more than 4 mm deep will be permitted. Gouges greater than 4 mm that remain from cutting shall be removed by grinding. All re-entrant corners shall be shaped notch free to a radius of at least 12 mm. Shearing, cropping and gas cutting shall be clean, reasonably square and free from any distortion.

3.01.04 Planning of edges

Planning or finishing of sheared or cropped edges of plates or shapes or of edges gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Engineer.

3.01.05 Clearances

The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2 mm at each end. The erection clearance at ends of beams web shall be not more than 3 mm at each end, but where for practical reasons greater clearance is necessary, suitably designed cheatings shall be provided.

3.02.00 Riveted and bolted construction

3.02.01 Holes

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, if the thickness of the material is not greater than the nominal diameter of rivet or bolt plus 3 mm subject to a maximum thickness of 16 mm provided that the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes for rivets or black bolts shall be not more than 1.5 mm or 2.0 mm (depending on whether the diameter of the rivet or bolt is less or more than or equal to 25 mm) larger in diameter than the nominal diameter of the rivet or black bolt passing through them.

Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance grade of BS as

specified in IS: 919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

Holes for rivets or bolts shall not be formed by gas cutting process.

3.02.02 Assembly

All parts of riveted members shall be well pinned or bolted and rigidly held together while riveting. Drifting to enlarge unmatching holes shall not generally be permitted. In case drifting is permitted to a slight extent during assembly, it shall not distort the metal or enlarge the holes. Holes that must be enlarged to admit the rivets or bolts shall be reamed. Poor matching of holes shall be cause for rejection. The component parts shall be so assembled that they are neither twisted not otherwise damaged, and shall be so prepared that the specified cambers, if any, are maintained.

Rivets shall ordinarily be hot driven, in which case their finished heads shall be approximately hemispherical in shape and shall be of uniform size throughout the work for rivets of the same size full, neatly finished and concentric with he holes. Rivets shall be heated uniformly to a temperature not exceeding 1 125°C they shall not be driven after their temperature has fallen below 540°C.

Rivets shall be driven by power riveters, of either compression or manually operated type, employing pneumatic, hydraulic or electric power. Hand driven rivets shall not be allowed unless in exceptional cases specifically approved by the Engineer. After driving, rivets shall be tight, shall completely fill the holes and their heads shall be in full contact with the surface. In case of countersunk rivets, the countersinking shall be fully filled by the rivet, any proudness of the countersunk head being dressed off flush, if required.

Riveted members shall have all parts firmly drawn and held together before and during riveting and special care shall be taken in this respect for all single riveted connections. For multiple riveted connections, a service bolt shall be provided in every third or fourth hole.

All loose, burnt, or otherwise defective rivets shall be cut out and replaced and special care shall be taken to inspect all single riveted connections. Special care shall also be taken in heating and driving long rivets. The Contractor shall prove the quality of riveting by cutting some rivets chosen at random by the Engineer. No extra payment will be made to the Contractor for such cutting and replacing. Riveting work, for any particular section or group, will be considered satisfactory when at least 90% of the corresponding cut rivets is found to be sound. If the ratio is below 75%, all the rivets in the particular

section or group shall be cut, removed and replaced and tested again at the Contractor's expense. For cases between 75% and 90% the engineer shall have the option to instruct cutting and replacing any number of further rivets at the Contractor's cost as he deems necessary.

Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified. In special cases, however, shop bolt connections may be allowed if shown on drawing or directed by the Engineer.

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project trough the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. In addition to the normal washer one spring washer or lock nut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified on the Drawings.

3.03.00 Welded Construction

3.03.01 General

Welding shall be in accordance with relevant Indian Standards and as supplemented in the Specification. Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS: 817.

3.03.02 Preparation of material

Surface to be welded shall be free from loose scale, slag, rust, grease, paint, and any other foreign material except that mill scale, which withstands vigorous wire brushing, may remain. Joint surfaces shall be free from fins and tears. Preparation of edges by gas cutting shall, wherever practicable, be done by a mechanically guided torch.

3.03.03 Assembling

Parts to be fillet welded shall be brought in, as close contact as practicable and in no event shall be separated by more than 4 mm. If the separation is 1.5 mm or greater, the size of the fillet welds shall be increased by the amount of the separation. The fit of joints at contact surfaces, which are not completely sealed by, welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than two degrees (2°).

The work shall be positioned for flat welding whenever practicable.

3.03.04 Welding Sequence

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shod splicing not more than three sub-sections, each made in accordance with this paragraph.

When required by the Engineer, welded assemblies shall be stress relieved by heat-treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Engineer.

3.03.05 Welding technique

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 m thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross-section. Groove welds made with the use of the backing of the same material, as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the contract.
To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

3.03. 12 Temperature

No welding shall normally be done on parent material at a temperature below (-) 5°C. However, if welding is to undertaken at low temperature, adequate

precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 5°C and 0°C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is hand warm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall be in no case be less than 20°C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

3.03. 13 Peening

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool, peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

3.03. 14 Equipment

These shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of a type and capacity as recommended by the manufacturers of electrodes or as may be approved by the engineer.

3.04.00 Finish

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-butted over the whole section with a clearance not exceeding 0.1 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc; after welding/riveting together, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles of channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 1.0 mm.

3.05.00 Slab bases and caps

Bases and caps fabricated out of steel slabs, except when cut material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. A bearing face, which is to be grouted direct to a foundation, need not be machined if such face is true and parallel to the upper face.

To facilitate grouting, holes shall be provided, where necessary, in stanchion bases for the escape of air.

3. 12.00 Lacing bars

The ends of lacing bars shall be neat and free from burns.

3. 13.00 Separators

Rolled section or built-up steel separators or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

3.14.00 Bearing Plates

Provision shall be made for all necessary steel bearing plates to take up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

3.15.00 Floor Grating

All grating units shall be rectangular in pattern and of pressure locked assembly. The size and spacing of bearing bars and cross bars shall be as approved in detailed drawings. Alternatively, diamond pattern grating if approved may be used.

The grating shall be made in panel units designed to span as indicated in structural steel framing drawing or as directed by the Engineer.

The grating units shall be finished free from warps, twists, or any other defects. Grating work shall include cutouts and clearance openings for all columns, pipes, ducts, conduits etc. The gratings shall be notched, trimmed, and neatly finished around components of the steel structures encountered. Binding strip shall be provided on the grating to suit the profile. Openings in gratings shall be provided with steel bar toe plates of not less than 5 mm thickness and 100 mm width.

Unless otherwise indicated on drawings, all penetrations of grating units shall be made up in split section, accurately fitted, and neatly finished. Grating units shall be provided with all necessary clips, bolts, lock washers etc. for proper assembly and installation on supporting steel members. Maximum deviation in linear dimension shall not exceed 12 mm.

3.10.00 Chequered Plates

Minimum thickness of chequered plate floorings, covers etc. shall be 6 mm O/P. Chequered plate shall be accurately cut to the required sizes and shapes and the cut edges properly ground. Stiffeners shall be provided wherever required from design consideration.

3.11.00 Architectural Clearances

Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

3.11.00 Shop connections

a) All shop connections shall be otherwise riveted or welded as specified on the Drawings.

b) Heads of rivets on surfaces carrying brick walls shall be flattened to 10 mm thick projection.

c) Certain connections, specified to be shop connections, may be changed to field connections if desired by the Engineer for convenience of erection and the contractor will have to make the desired changes at no extra cost to the exchequer.

3.13.00 Castings

Steel castings shall be annealed.

3.14.00 Shop erection

The steelwork shall be temporarily shop-erected complete or as directed by the Engineer so that accuracy of fit may be checked before dispatch. The parts shall be shop-erected with a sufficient number of parallel drifts to bring and keep the parts in place. In case of parts drilled or punched using steel jigs to make all similar parts interchangeable, the steelwork shall be shop erected in such a way as will facilitate the check of interchange ability.

3.15.00 Shop painting

3.15.01 General

Unless otherwise specified, steelwork, which will be concealed by interior building finish, need not be painted; steelwork to be encased in concrete shall not be painted. Unless specifically exempted, all other steelwork shall be given one coat of shop paint, applied thoroughly and evenly to dry surfaces which have been cleaned, in accordance with the following paragraph, by brush, spray, roller coating, flow-coating or dipping as may be approved by the Engineer.

After inspection and approval and before leaving the shop, all steelwork specified to be painted shall be cleaned by hand-wire brushing or by other methods of loose mill scale, loose rust, weld slag or flux deposit, dirt and other foreign matter. Oil and grease deposits shall be removed by the solvent. Steelwork specified to have no shop paint shall, after fabrication, be cleaned of oil or grease by solvent cleaners and be cleaned of dirt and other foreign material by trough sweeping with a fibre brush.

3.15.02 Inaccessible parts

Surfaces not in contact, but inaccessible after assembly, shall receive two coats of shop paint, positively of different colours to prove application of two coats before assembly. This does not apply to the interior of sealed hollow sections.

3.15.03 Contact surfaces

Contact surface shall be cleaned in accordance with sub-clause 3.13.1 before assembly.

3.15.04 Finished surfaces

Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

3.15.05 Surfaces adjacent to field welds

Unless otherwise provided for, surfaces within 50 of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

3.16.00 Galvanizing

3.16.01 General

Structural steelwork for switchyard or other structures as may be specified in the contract shall be hot dip galvanized in accordance with the American Society for Testing and Materials Specification ASTM-A 123 or IS: 2629 - Recommended practice for Hot-Dip Galvanizing of Iron and steel. Where the steel structures are required to be galvanized the field connection materials like bolts, nuts and washers shall also be galvanized.

3.16.02 Surface Preparation

All members to be galvanized shall be cleaned, by the process of pickling of rust, loose scale, oil, grease, slag and spatter of welded areas and other foreign substances prior to galvanizing. Pickling shall be carried out by immersing the steel in an acid bath containing either sulphuric or hydrochloric acid at a suitable concentration and temperature. The concentration of the acid and the temperature of the bath can be varied, provided that the pickling time is adjusted accordingly.

The pickling process shall be completed by thoroughly rinsing with water, which should preferably be warm, so as to remove the residual acid.

3.16.03 Procedure

Galvanizing shall be carried out by hot dip process in a proper and uniformly heated bath. It shall meet all the requirements when tested in accordance with IS: 2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS: 4759 - Specification for Hot-dip zinc coatings on Structural Steel & other allied products.

After finishing the threads of bolts, galvanizing shall be applied over the entire surface uniformly. The threads of bolts shall not be machined after galvanizing and shall not be clogged with zinc. The threads of nuts may be tapped after galvanizing but care shall be taken to use oil in the threads of nuts during erection.

The surface preparation for galvanizing and the process of galvanizing itself, shall not adversely affect the mechanical properties of the materials to be galvanized. Where members are of such lengths as to prevent complete dipping in one operation, great care shall be taken to prevent warping.

Materials on which galvanizing has been damaged shall be acid stripped and re-galvanized unless otherwise directed, but if any member becomes damaged after leaving been dipped twice, it shall be rejected. Special care shall be taken

not to injure the skin on galvanized surfaces during transport, handling, and erection. Damages, if occur, shall be made good in accordance or as directed by the Engineer.

4.00.00 INSPECTION, TESTING, ACCEPTANCE CRITERIA AND DELIVERY

4.01.00 Inspection

Unless specified otherwise, inspection to all, work shall be made by the or Engineer's representative at the place of manufacture prior to delivery. The Engineer or his representative shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork under this Contract and he shall be afforded all reasonable facilities for satisfying himself that the fabrication is being done in accordance with the provisions of this Specification.

The Contractor shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Engineer to carry out inspection and/or tests in accordance with the Contract. The Contractor shall guarantee compliance with the provisions of this Specification.

4.02.00 Testing and Acceptance Criteria

4.02.01 General

The Contractor shall carry out sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own Cost. The Contractor shall get the specimens tested in a laboratory approved by the Engineer and submit to the Engineer the test results in triplicate within 3 (three) days after completion of the test.

4.02.02 Steel

All steel supplied by, the Contractor shall conform, to the relevant Indian Standards. Except otherwise mentioned in the contract, only tested quality steel having mill test reports shall be used. In case unidentified steel materials are permitted to be used by the Engineer, random samples of materials will be taken from each unidentified lot of 50 M.T or less of any particular section for tests to conform to relevant Indian Standards. Cost of all tests shall be born by the contractor.

All material shall be free from all imperfections, mill scales, slag intrusions, laminations, fittings, rusts etc. that may impair their strength, durability, and appearance.

4.02.02 Welding

a) The weld surface shall be cleaned with steel wire brush to remove spatter metal, slag etc. and 100% of welds shall be inspected visually for size, length of weldment and external defects. Weld gauges shall be used for checking weld sizes. The surface shall be clean with regular beads and free from slags, cracks, blow-holes etc.

b) Non-destructive examination shall be carried out to determine soundness of weldments as follows:

   i) 10% at random on fillet-joints.

   ii) 100% on all butt-joints.

c) Should the ND tests indicate defects like improper root penetration, extensive blowholes, slag intrusion etc., such welds shall be back gauged, joints prepared again and rewelded. All defects shall be rectified by the Contractor at no extra costs.

d) All electrodes shall be procured from approved reputed manufacturers with test certificates. The correct grade and size of electrode, which has not deteriorated in storage, shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian Standards or other equivalents. For every 50 tones of welded fabrication, the Engineer may ask for 1(one) test-destructive or non-destructive including X -ray, ultrasonic test or similar, the cost of which shall be borne by the Contractor.

4.02.04 Rivets, bolts, nuts and washers

All rivets, bolts, nuts, and washers shall be procured from M/s. Guest Keen William Ltd. or equivalent and shall confirm to the relevant Indian Standards. If desired by the Engineer, representative samples of these materials may have to be tested in an approved laboratory and in accordance with the procedures described in relevant Indian Standards. Cost of all such testing shall have to be borne by the Contractor. In addition to testing the rivets by hammer, 2% (two per cent) of the rivets done shall have to be cut off by chisels to ascertain the fit, quality of material and workmanship. The removal of the cut rivets and re-installing new rivets shall be done by the Contractor at his own cost.

4.02.05 Shop painting

All paints and primers shall be of standard quality and procured from approved manufacturers and shall conform to the provisions of the relevant Indian Standards.

4.02. 12 Galvanizing

All galvanizing shall be uniform and of standard quality when tested in accordance with IS: 2633 - Method for testing uniformity of coating on Zinc Coated Articles and 15: 4759 - specification for Hot-Dip Zinc Coatings on Structural Steel & other allied products.

4.03.00 Tolerance

The tolerances on the dimensions of individual rolled steel components shall be as specified in IS: 1852 - specification for rolling and Cutting Tolerances for Hot-rolled Steel Products. The tolerances on straightness, length etc. of various fabricated components (such as beams and girders, columns, crane gantry girder etc.) of the steel structures shall be as specified in IS: 721 - Tolerances for Fabrication of Steel Structures.

4.04.00 Acceptance

Should any structure or part of a structure be found not to comply with any of the provisions of this specification, the same shall be liable to rejection. No Structure or part of the structure once rejected, shall be offered again for test, except in cases where the Engineer considers the defects rectifiable. The Engineer may, at his discretion, check some of the tests at an appropriate laboratory at the contractors cost.

When all tests to be performed in the Contractor's shop under the terms of this contract have been successfully carried out, the steelwork will be accepted forthwith and the Engineer will issue acceptance certificate, upon receipt of which, the items will be shop painted, packed and dispatched. No item to be delivered unless an acceptance certificate for the same has been issued. The satisfactory completion of these tests or the issue of the certificates shall not bind the Owner to accept the work, should it, on further tests before or after erection, be found not in compliance with the Contract.

4.05.00 Delivery of materials

4.05.01 General

The Contractor will deliver the fabricated structural steel materials to site with all necessary field connection materials in such sequence as will permit the most efficient and economical performance of the erection work. The Owner may prescribe or control the sequence of delivery of materials, at his own discretion.

4.05.02 Marking

Each separate piece of fabricated steelwork shall be distinctly marked on all surfaces before delivery in accordance with the markings shown on approved erection drawings and shall bear such other marks as will further facilitate identification and erection.

4.05.03 Shipping

Shipping shall be strictly in accordance with the sequence stipulated in the agreed Programme. Contractor shall dispatch the materials to the e worksite securely protecting and packing the materials to avoid loss or damage during transport by rail, road or water. All parts shall be adequately braced to prevent damage in transit.

Each bundle, bale or package delivered under this contract shall be marked on as many sides as possible and such distinct marking (all previous irrelevant markings being carefully obliterated) shall show the following:

a) Name and address of the consignee

b) Name and address of the consignor

c) Gross weight of the package in tonnes and its dimensions

d) Identification marks and/or number of the package

e) Custom registration number, if required

All markings shall be carried out with such materials as would ensure quick drying and indelibility.

Each component or part or piece of material when shipped, shall be indelibly marked and/or tagged with reference to assembly drawings and corresponding piece numbers.

Each packing case shall contain in duplicate in English a packing list pasted on to the inside of the cover in a water-proof envelope, quoting especially -

a) Name of the Contractor

b) Number and date of the Contract

c) Name of the office placing the contract

d) Nomenclature of stores

e) A schedule of parts or pieces, giving the parts or piece number with reference to assembly drawings and the quantity of each.

The shipping dimensions of each packing shall not exceed the maximum dimensions permissible for transport over the Indian Railways/Roads.

After delivery of the materials at site, all packing materials shall automatically become the property of the Owner.

Notwithstanding anything stated hereinbefore, any loss or damage resulting from inadequate packing shall be made good by the Contractor at no additional cost to the Owner. When facilities exist, all shipments shall be covered by approved Insurance Policy for transit at the cost of the Contractor.

The contractor shall ship the complete materials or part on board a vessel belonging to an agency approved by the Owner or on rail and/or road transport as directed. The Contractor shall take all reasonable steps to ensure correct appraisal of freight rates, weights and volumes and in no case will the Owner be liable to pay any warehouse, wharfage, demurrage and other charges.

If, however, the Owner has to make payment of any of the above-mentioned charges, the amount paid will be deducted from the bills of the Contractor.

Necessary advice regarding the shipment with relevant details shall reach the Engineer at least a week in advance.

5.00.00 INFORMATION TO BE SUBMITTED

5.01.00 With Tender

The following information is required to be submitted with the Tender:

a) Progress Schedule

The Contractor shall quote in his Tender a detailed schedule of progress of work and total time of completion, itemizing the time required for each of the following aspects of work.

i) Preparation and approval of fabrication drawing

ii) Procurement of Materials

iii) Fabrication and shipping of all anchor bolts

iv) Fabrication and shipping of main steelwork.

v) Fabrication and shipping of steelwork for bunkers, tanks and/or silos as applicable.

vi) Fabrication and shipping of all other remaining steelwork including miscellaneous steelwork.

vii) Final date of completion of all shipments.

b) Shop

Location of the Tenderer's fabrication workshop giving details of equipment, manpower, the total capacity, and the capacity that will be available exclusively for this contract shall be submitted.

5.02.00 After Award

After award of the Contract the successful Tenderer is to submit the following:

a) Complete fabrication drawings, material lists, cutting lists, rive and bolt lists, field welding schedules based on the approved design drawings prepared by him in accordance with the approved schedule.

b) Monthly Progress Report with necessary photographs in six (6) copies to reach the Engineer on or before the 7th day o. each month, giving the up-to-date status of preparation of detailed shop drawings, bill of materials, procurement of materials, actual fabrication done, shipping and all other relevant information.

c) Detailed monthly material reconciliation statements relevant to the Work done and reported in the Progress Report, giving the stock at hand of raw steel, work in progress, finished materials.

d) Results of any test as and when conducted and as require by the engineer.

e) Manufacturer’s mill test report in respect of steel materials, rivets, bolts, nuts, and electrodes as may be applicable.

6.00.00 RATES AND MEASUREMENT

6.01.00 Rates

6.01.01 The items of work in the Schedule of items describe the work in brief. The various items of the Schedule of items shall be read in conjunction with these specifications including amendments and additions, general conditions of contract, special conditions of contracts, and other tender documents, if any. For each item of Schedule of Items, the bidder's rates shall include the activities covered in the description of the item as well as all necessary operations described in the Specifications.

6.01.02 The bidder's rates shall include cost of all minor details which are obviously and fairly intended and which may not have been included in the description in these documents but are essential for the satisfactory completion of the work. Rates shall also include for taking all safety measures.

6.01.03 The bidder's -rates for all items of schedule of items shall include complete cost towards plant, equipment, erection and dismantling of scaffolding, men, materials and consumables, skilled and unskilled labour, levies, taxes, royalties, duties, transport, storage, repair/rectification/maintenance until handing over, contingencies, overhead and all incidental items not specifically mentioned but reasonably implied and necessary to complete the work.

6.01.04 No claims shall be entertained, if the details shown on the `Released for Construction' drawings differ from those shown on the bid/tender drawings.

6.01.05 Rates shall be inclusive of all leads and lifts/elevation.

6.01.06 The bidder's rates for Structural Steel shall include for fabrication and erection, transportation to site, preparation checking collecting and distributing of the fabrication drawings and design calculations, erection scheme, alignment, welding, including preheating and post heating, testing of welders, inspection of welds, visual inspection, non destructive and special testing, rectification and correction of defective welding works, production test plate, inspection and testing, erection scheme, protection against damage in transit, stability of structures, etc. The rates shall also be inclusive of providing and installing temporary structures, transport of Owner issue material from store, return of surplus/waste steel materials including cut pieces'/waste steel, provision of additional butt/weld joint to reduce the wastage and all other general, special, such requirements as may be required, for the successful completion of the work.

The rates for fabrication are inclusive of all tests on welds and material and no extra shall be payable for quality tests specified for fabrication of structure in shop or at site.

Separate BOQ items for test on welds like radiography or Ultrasonic, DPT, magnetic particle tests are kept for tests on material/fabrication not covered under regular fabrication item of BOQ.

6.01.07 The bidder's rates for foundation bolts assembly shall include fabrication, threading, heat treatment, erection, installation, and alignment of complete bolt assembly with nuts, locknuts, anchor plates, stiffener plates, protective tape, etc. This shall also include the cost of all materials not issued by the Owner. Material issued by Owner will be specified in GCC.

6.01.08 The bidder’s rates for application of inorganic primer shall include surface preparation to near white metal surface by blast cleaning, abrasives, touch up painting, suitable enclosure to avoid contamination and the necessary statutory approval from the factory inspector/pollution control board etc. regarding the method of blast cleaning and abrasives used, and getting approval of the specialized agency supplying the primer specified.

6.01.09 The bidder's rates for application of finish painting system shall include surface preparation, application of intermediate (under) coat, finish coat and final finish coat, and getting approval of the specialized agency supplying the finish paint.

6.01.10 The bidder's rates for electro-forged gratings (if specified) shall include supply, fabrication, transportation to the site, erection and alignment of factory made electro-forged gratings, all taxes, duties thereon etc. The rates shall also include preparation of grating design for different spans and load intensifies, preparation of design and fabrication drawings, edge preparation, blast cleaning followed by finish paint.

6.01.11 The bidder's rates for galvanization of factory made electro-forged gratings (if specified) shall include the application of hot dipped galvanization as finish over the fabricated gratings and the treatment to be given for prevention of white storage stains, as per the technical Aspiration.

6.01.12 The bidder’s rates for permanent mild steel bolts, nuts and washers shall include the supply and fixing of such bolts, nuts and washers in position, for various types of Structural Steel works, as per the technical specification.

6.01.13 The bidder’s rates for high strength structural bolts, nuts and washers shall include the supply and fixing of such bolts, nuts and washers in position, for various types, of Structural Steel works, as per the technical specification.

6.01.14 The bidder's rates for dismantling, additions to, alterations in and/or modifications shall be inclusive of all operations such as lowering of material, carriage etc., as mentioned in the technical specification. Unutilised steel pieces cut/removed shall be returned to the project stores free of charge. Non-return of unublized steel pieces to the Owner's store would be considered as wastage and recovery would be affected as per the provision of contract for structural steel consumption. This shall not include the weight of temporarily dismantled/supported members, connected member.

The bidder should prepare an optimised cutting plan as per fabrication drawing to utilise the steel material upto maximum extent and minimise the wastage/scrap. Quantity of wastage/scrap of material should be limited to the percentage mentioned elsewhere in the conditions of tender/ contract specifications.

6.01.15 The bidder's rates for re-erection of erection marks after additions to, alterations in and/or modifications shall be inclusive of all operations mentioned in technical specification for the calculated weight of the rectified/modified erection mark rejected at site. This shall not include the weight of temporarily dismantled/supported members, connected member. All the operations mentioned above for restoring such members shall be carried out at no extra cost. The work of erection of any erection mark which has not been dismantled but have been modified/rectified before erection shall not be paid under this item but shall be paid under relevant item of fabrication and erection of steel work of Schedule of items for the modified weight.

6.01.16 The bidder's rates for PTFE shall include design, supply, transportation of the complete assembly with guides and dust protection cover and installation of bearings in position drilling, bolting, erecting aligning etc. along with any taxes, duties thereon etc.

6.01.17 The bidder's rates for Stainless Steel hopper (if specified) shall include fabrication and erection, transportation to site, preparation checking collecting and distributing of the fabrication drawings and design calculations, all other operations mentioned in the technical specification. The rates shall also include for erection scheme, alignment, making cutting plan, cutting, jointing, bending, rolling, grinding, drilling, bolting, assembly, edge preparation, welding including pre-heating, post-heating, testing of welders, inspection of welds, inspection and testing, protection against damage in transit, stability of structures, installation of temporary structures etc. The rates shall also be inclusive of providing and installing temporary structures, transport of Owner issue material from store, return of surplus / waste steel materials including cut pieces'/waste steel, provision of additional butt / weld joint to reduce the wastage and all other general, special, such requirements as may be required, for the successful completion of the work.

6.01.18 The bidder's rates for preformed flexible open ended bellow strap of neoprene (if specified) shall include supply and transportation, installation in position, drilling, bolting, aligning etc. complete along with any taxes, duties thereon etc.

6.01.19 The bidder's rates for Stainless Steel Hand Rail (if specified) shall include complete Hand Rail including, materials, fabrication, grinding & finishing, stainless steel beading, stainless steel cleats, stainless steel fasteners, neoprene gaskets, preparation of shop drawing but excluding the cost of glazing. The Owner shall supply no material for this item of work.

6.02.00 MODE OF MEASUREMENT

6.02.01 The measurement for the item of foundation bolts assembly including that of nuts; locknuts shall be based on the calculated weight of steel installed in Metric Tonne, corrected to second place of decimal. The weight of the foundation bolt shall be calculated in the same way as that done for the item of fabrication, erection, alignment of structural steel. The weight of the nut / locknut shall be taken as per actual weight supplied by the contractor and accepted by the Engineer.

6.02.02 The measurement for the item of fabrication, erection, alignment, welding, etc. of structural steel work shall be based on the approved weight of steel nearest to a Kg, by applying the unit weight as adopted at the time of issue of structural steel on the measurements worked out as given below.

6.02.03 For ISMB, ISMC, ISA, flats, round bars, square bars and pipes, length shall be taken as per distance between planes normal to the axis of the member passing through the extreme points of the section.

6.02.04 Gussets plates in trusses, and bracings, brackets plates, stiffeners, and skew cuts if any in plates for butt welds, the area shall be assumed as the minimum circumscribed rectangle. However, deduction for any notch/skew cut shall be made as mentioned in clause no-6.02.06.

6.02.05 For bunker wall plates, the minimum-circumscribing rectangle of the individual plate/pieces out of which these wall plates are assembled by butt-welding, shall be measured. Care shall be taken to ensure maximum utilization of cut-pieces generated by providing extra butt joints (for which no extra payment shall be made).

6.02.06 For all other plates, where the area of any notch/skew cut in the plate is less than 0.05 sq.m. the area of the plate shall be assumed as that of the minimum circumscribing rectangle for the purpose of measurement and calculation of area for the purpose of payment. However, if the area of any notch/skew cuts in a plate is more than 0.05 sq.m, the area of notch/skew cut shall be deducted

from assumed minimum circumscribing rectangular area for the purpose of payment.

6.02.07 No deduction shall be made for the hole in the members, if the area of individual hole is less than 0.05 sq.m. The weight shall be calculated by deducting the area of holes, if area of individual hole is more than 0.05 sq.m.

6.02.08 All cut-pieces and scrap generated due to cutting of holes, skew-cuts of plates, gussets, brackets, stiffeners, etc. shall be stacked separately and handed over to the project stores without being considered for material accounting as the circumscribing rectangle has been considered for payment.

6.02.09 The splice plate shown in the fabrication drawing or approved by the Engineer shall only be measured for payment.

6.02.10 The weight of permanent bolts, washers and nuts and welds shall not be included in the weights of the members. No extra payment shall be made for welding/bolting.

6.02.11 The bolts and nuts required for erection purpose shall not be paid for and may be taken away by the Contractor after final welding for members. Erection boltholes left after removal of erection bolts shall be suitably plugged with welds.

6.02.12 The measurement for the item of application of inorganic primer including blast cleaning of steel surfaces shall be based on the weight on which the zinc silicate primer is applied, after blast cleaning in Metric Tonne, corrected to third place of decimal. The weight shall be the weight as approved, for erection mark/element of the mark painted, for payment of the item of fabrication and erection of structural steel works.

6.02.13 The measurement for the item of application of finish primer system shall be based on the weight on which the epoxy based finish primer is applied in Metric Tonne, corrected to third place of decimal. The weight shall be the weight as approved, for erection mark/element of the mark painted, for payment of the item of fabrication and erection of structural steel works.

6.02.14 The measurement for the item of gratings shall be based on the actual weight in Kgs, corrected to second place of decimal, as supplied by the Contractor, and accepted by the Engineer. Nothing extra shall be payable for making cutouts, notches, openings of any profile, trimming profiles etc. in the grating units.

6.02.15 The measurement for the item of hot dipped galvanization of gratings shall be based on the actual weight in Kgs, corrected to second place of decimal of gratings galvanized by the Contractor and accepted by the Engineer.

6.02.16 The measurement for the item of permanent bolts with nuts and washers shall be based on the actual weight in Kgs, corrected to second place of decimal, as supplied by the Contractor and accepted by the Engineer, and as per the approved bolts and nuts schedules.

6.02.17 The measurement for the item of High Strength Structural bolts with nuts and washers shall be based on the actual weight in Kgs, corrected to second place of decimal, as supplied by the Contractor and accepted by the Engineer, and as per the approved bolts and nuts schedules.

6.02.18 The measurement for the item of the work of dismantling, additions, alterations, reerection etc. shall be as given below

6.02.19 For dismantling, the unmodified weight of the actually dismantled erection marks shall only be measured.

6.02.20 For the work of addition to, alteration in and / or modification of 'erection marks' either in erected position or in the fabrication yard, measurement of weight for payment purpose shall be calculated as the arithmetic sum of weight of steel cut and removed from the erection mark, weight of steel reutilised out of such cut and removed pieces and weight of additional new steel pieces added to the erection mark.

6.02.21 For re-erection the weight of the modified erection mark shall only be measured.

6.02.22 The weight shall be measured nearest to kg. and shall be arrived in a manner similar to the measurement for the item of fabrication, erection, alignment and welding of structural steel.

6.02.23 The measurement for the item of PTFE bearings shall be based on the load carrying capacity of PTFE in MT, corrected to third place of decimal, supplied by the contractor and as accepted by the Engineer and as per the approved bearing schedule, for the total vertical load carrying capacity, for all bearings.

6.02.24 The measurement for the item of stainless steel hopper shall be based on the actual finished weight of hopper weight in Kgs, corrected to second place of decimal. The hopper weight shall be arrived by multiplying of the inner surface area of the hopper with the unit weight of the hopper plate.

6.02.25 The measurement for the item of flexible open-ended bellows straps of neoprene shall be based in running meter, corrected to second place of decimal. Bellow Straps shall be supplied as per the requirement of the approved drawings. The measurement shall be done for the inner circumference of the bunker on which neoprene has been fixed and for the length supplied by the Contractor 'and as accepted by the Engineer.

6.02.26 The measurement for the item of Stainless Steel Hand Railing shall be based on finished weight of handrail in Kgs corrected to second place of decimal. The weight shall also include the weight of Stainless Steel fasteners, Stainless Steel beading, Stainless Steel cleats etc. The weight shall be the finished weight of Hand Rail, as accepted by the Engineer.

VOLUME: II B

SECTION - D
(PART I)

SUB-SECTION – D 18

ERECTION OF STRUCTURAL STEELWORK

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
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SUB-SECTION – D 18

ERECTION OF STRUCTURAL STEELWORK

1.00.00 SCOPE

This specification covers the erection of structural steelwork including receiving and taking delivery of fabricated structural steel materials arriving at site, installing the same in position, painting and grouting the stanchion bases all complete as per Drawings, this Specification and other provision of the Contract.

2.00.00 GENERAL

2.01.00 Work to be provided for by the Contractor, unless otherwise specified in the Contract, shall include but not be limited to the following:

a) The Contractor shall provide all construction and transport equipment, tools, tackle, consumables, materials, labour, and supervision required for erection of the structural steelwork.

b) Receiving, unloading, checking, and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site. The Contractor shall pay all demurrage and/or wharfage charges etc. on account of default on his part.

c) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, riveting, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and/or as directed by the Engineer. If necessary suitable temporary approach roads to be built for transportation of fabricated steel structures.

d) Checking centre lines, levels of all foundation blocks including checking line, level, position and plumb of all bolts and pockets. Any defect observed in the foundation shall be rectified with Engineer's approval. The Contractor shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.

e) Aligning, plumbing, levelling, riveting, bolting, welding and securely fixing the fabricated steel structures including floor gratings, chequered plates etc. in accordance with the Drawings or as directed by the Engineer.

f) Painting of the erected steel structures.

g) All minor modifications of the fabricated steel structures as directed by the Engineer including but not limited to the following:

i) Removal of bends, kinks, twists etc. for parts damaged during transport and handling.

ii) Cutting, chipping, filling, grinding, etc. if required for preparation and finishing of site connections.

iii) Reaming of holes for use of higher size rivet or bolt if required.

iv) Refabrication of parts damaged beyond repair during transport and handling or refabrication of parts, which are incorrectly fabricated.

v) Fabrication of parts omitted during fabrication by error, or subsequently found necessary.

vi) Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.

vii) Carry out tests in accordance with this specification.

2.02.00 Work by Others

No work under this Specification will be provided for by any agency other than the Contractor unless specifically mentioned elsewhere in the contract.

2.03.00 Codes and Standards

All work under this Specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specification and codes of Practice of equivalent:

IS: 800 - Code of practice for general construction in steel.

IS: 456 - Code of practice for main or reinforced concrete.

2.04.00 Conformity with Designs

The Contractor will erect the entire fabricated steel structure, align all the members, complete all field connections and grout the foundations all as per the provisions of this specification and the sequence and the design criteria laid down by the Engineer. All work shall conform to the provisions of this specification and /or instructions of the engineer. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specifications and/or the instructions o the Engineer.

2.05.00 Material

2.05.01 General

All fabricated steel structures and connection materials shall be supplied by the Contractor to the site. The Contractor shall take delivery from railway wagons or trucks at site, and unload the materials and perform all formalities like checking of materials and attend to insurance matters in accordance with Sub-Clause 2.01.00 and as specified hereinbefore.

2.05.02 Materials to conform to Indian standards

All materials required to be supplied by the Contractor under this contract shall conform to the relevant Indian Standard specifications.

2.06.00 Storage of Materials

2.06.01 General

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site, failing which, the engineer shall be at liberty to get the materials removed by agency and the cost incurred thereof shall be realised from the Contractor's dues.

2.06.02 Yard

The Contractor will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other raw steel materials such as structural sections and plates as required. The yard shall have facilities like drainage, lighting, and suitable access for large cranes, trailers, and other heavy equipments. The yard shall be fenced all around with security arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access for cranes, trailers and other equipment for use in erection work in proper sequence in accordance with the approved Programme of work.

The Tenderer must visit the site prior to submission of his tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. all of which shall be carried out by the Contractor at his own cost as directed by the Engineer.

2.06.03 Covered Store

All field connection materials, paints, cement etc. shall be stored on well designed racks and platforms off the ground in a properly covered store building to be built at the cost of the Contractor.

2.07.00 Quality Control

The contractor shall establish and maintain quality control procedures for different items of work and materials as may be directed by the Engineer to assure compliance with the provisions of the Contract and shall submit the records of the same to the Engineer. The quality control operation shall include but not be limited to the Following items of work:

i) Erection: Lines, levels, grades, plumbs, joint characteristics including tightness of bolts.

ii) Grouting: Cleaning and roughness of foundation, quality of materials used for grouting, admixtures, consistency, and strength of grout.

iii) Painting: Preparation of surface for painting, quality of primers and paints, thinners, application and uniformity of coats.

2.08.00 Taking Delivery

The Contractor shall take delivery of fabricated structural steel and necessary connection materials from railhead/trucks as may be necessary and as directed by the Engineer. He shall check, unload; transport the materials to his stores for proper storing at his own cost. The Contractor shall submit claims to insurance or other authorities and pursue the same in case of loss or damage during transit and handling and all loss thereof shall be borne by him.

The Contractor shall also take all precautions against damage of the materials in his custody after taking delivery and till the same are erected in place and accepted. The Contractor shall salvage, collect, and deliver all the packing materials to the Owner free of charge.

3.00.00 WORKMANSHIP

3.01.00 Erection

3.01.01 Plant and Equipment

The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be thoroughly verified. They shall be efficient, dependable, in good working condition and shall have the approval of the Engineer.

3.01.02 Method and sequence of erection

The method and sequence of erection shall have the prior approval of the Engineer. The Contractor shall arrange for most economical method and sequence available to him consistent with the drawings and specifications and other relevant stipulations of the contract.

3.01.03 Temporary Bracing

Unless adequate bracing is included as a part of the permanent framing, the erector during erecrtion shall install, free of cost to the Owne, temporary guys and bracings where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well as loads due to erection equipment and erection operations.

If additional temporary guys are required to resist wind or seismic forces acting upon components of the finished structure installed by others during the course of the erection of the steel framing, arrangement for their installation by the erector shall be made free of cost to the Owner.

The requirement of temporary bracings and guys shall cease when the structural steel is once located, plumbed, levelled, aligned, and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Engineer.

The temporary guys, braces, false work, and cribbing shall not be the property of the Owner and they may be removed immediately upon completion of the steel erection.

3.01.04 Temporary Floors for Buildings

It shall be the responsibility of the Contractor to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of Parliament and/or bylaws of state, Municipal or other local authorities.

3.01.05 Setting Out

Positioning and levelling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the approved Drawings and to the satisfaction of the Engineer. For heavy columns, etc. the Contractor shall set proper screed bars to maintain proper level. No extra payment shall be made for this.

Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance under this Specification.
No permanent field connections by riveting, bolting or shall be carried out until proper alignment and plumbing has been attained.

3.01.06 Field Riveting

All rivets shall be heated and driven with pneumatic tools. Hand passing or "throwing" of rivets are desirable. Any other method of conveying hot rivets from the furnace to the driving point must be approved by the engineer. No-cold rivets shall be driven. All other requirements of riveting including quality and acceptance criteria shall be in accordance with the relevant portions of the Specification for Fabrication of Structural Steelwork of the Project.

3.01.07 Field Bolting

All relevant Portions in respect of bolted construction of the Specification for Fabrication of Structural Steelwork applicable to the Project shall also be applicable for field bolting in addition to the following:

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other, defects that would prevent solid seating of the parts. Contact surfaces within friction type joints shall be free of oil, paint, lacquer, or galvanizing.

All high tensile bolts shall be tightened to provide, when all fasteners in the joint are tight, the required minimum bolt tension by any of the following methods.

a) Turn-of-nut Method

When the turn-of-nut method is used to provide the bolt tension, there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the Joint are brought into good contact with each other. 'Snug tight" is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in Table-I with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation

there shall be no rotation of the part not turned by the wrench.

TABLE-I

Bolts length not exceeding 8 times Dia or 200 mm	Bolt length exceeding 8 times Dia or 200 mm	Remarks
1/2 turn	2/3 turn	Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation-30° over or under.

Bolts may be installed without hardened washers when tightening is done by the turn -of-nut -method. However, normal washers shall be used.

Bolts tightened by the turn-of-nut method may have the outer face of the match-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks can be made by the wrench operator by suitable means after the bolts have been brought up snug tight.

b) Torque Wrench Tightening

When torque wrenches are used to provide the bolt tensions, the bolts shall be tightened to the torques specified in TABLE-II (See Note below the Table). Nuts shall be in tightening motion when torque is measured. When using torque wrenches to install several bolts in a single joint, the wrench shall be returned to touch up bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the required tension.

TABLE-II

Nominal Bolt Diameter (mm) (Kg.M) of IS:1367	Torque to be applied for bolt class 8.8
20	59.94
22	81.63
24	103.73

Note: The above torque values are approximate for providing tensions of 14. 7 T for 20 mm dia.; and 21.2 T for 24 mm dia. bolts under moderately lubricated condition. The torque wrench shall be calibrated at least once daily to find out the actual torque required to produce the above required tension in the bolt by placing it in a tension indicating device. These torques shall be applied for tightening the bolts on that day with the particular wrench.

In either of the above two methods, if required, for bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating.

Impact wrenches if used shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds. Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled. Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications. All other requirements regarding assembly and bolt tightening shall be in accordance with this sub clause.

3.01.08 Field Welding

All field assembly and welding shall be carried out in accordance with the requirements of the specification for fabrication work applicable to the project, excepting such provisions therein which manifestly apply to shop conditions only. Where the fabricated structural steel members have been delivered painted, the paint shall be removed before field welding for a distance of at least 50 mm on either side of the joints.

3.01.09 Holes, Cutting and Fitting

No cutting of sections, flanges, webs, cleats, rivets, bolts, welds etc. shall be done unless specifically approved and /or instructed by the Engineer.

The erector shall not cut, drill, or otherwise alter the work of other trades, unless such work is clearly specified in the Contract or directed by the Engineer. Wherever such work is obtain specified the Contractor shall obtain complete information as to size, location and number of alterations prior to carrying out any work. The Contractor shall not be entitled for any payment on account of any such work.

3.02.00 Drifting

Correction of minor misfits and reasonable amount of reaming and cutting of excess stock from rivets will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge

holes as necessary to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming, shall not be allowed.

Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be called to the attention of the Engineer and approval of the method of correction obtained. The use of gas cutting torches at erection site is prohibited.

3.03.00 Grouting of stanchion bases and bearings of beams and girders on stone, brick or concrete (Plain or reinforced)

Grouting shall be carried out with Ordinary Cement grout as described below:

The mix shall be one (1) part cement and one (1) part sand and just enough water to make it workable. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water and any accumulated water shall be removed. These shall be placed under expert supervision, taking care to avoid air locks. Edges shall be finished properly. If the thickness of grout is 25 mm or more, two (2) parts of 6 mm down graded stone chips may be added to the above noted cement-sand grout mix, if required, by the Engineer or shown on the drawings.

No grouting shall be carried out until a sufficient number of bottom lengths of stanchions have been properly lined, leveled, and plumbed and sufficient floor beams are tied in position.

Whatever method of grouting is employed, the operation shall not be carried out until the steelwork has been finally levelled and plumbed, the stanchion bases being supported meanwhile by steel wedges, and immediately before grouting, the space under steel shall be thoroughly cleaned.

If required by the Engineer, certain admixtures like aluminium powder, “ironite” or equivalent, may be required to be added to the grout to enhance certain desirable properties of the grout. Approved non-shrink pre-mixed grout having required flowability and compressive strength may also be used with Engineer's approval.

3.04.00 Painting after Erection

Field painting shall only be done after the structure is erected, levelled, plumbed, aligned and grouted in its final position, tested and accepted by the Engineer. Normally, final painting shall be done only after the floor slabs are concreted and masonry walls are built. However, touch up painting, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the Contractor free of cost to the Owner. The materials and specification for such painting in the field shall be in accordance

with the requirements of the specification for fabrication of structural steelwork applicable for the project.

Painting shall not be done in frosty or foggy weather or when humidity is such as to cause condensation on the surfaces to be painted. Before painting of steel, which is delivered unpainted, is commenced, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.

All field rivets, bolts, welds, and abrasions to the shop coat shall be spot painted with the same paint used for the shop coat. Where specified, surfaces, which will be in contact after site assembling, shall receive a coat of paint (in addition to the shop coat, if any) and shall be brought together while the paint is still wet.

Surface, which will be inaccessible after field assembly shall receive the full, specified protective treatment before Bolts and fabricated steel members who are galvanized or otherwise treated and steel members to be encased shall not be painted.

The final painting shall be of tow coats of Synthetics Enamel painting or Aluminium paint of approved manufacture as per the approved "Schedule of Painting". The shades shall also be as per the approved schedule. Synthetic enamel paint shall conform to IS: 2932.

3.05.00 Final cleaning up

Upon completion of erection and before final acceptance of the work by the Engineer, the contractor shall remove free of cost all false work, rubbish and all Temporary Works resulting in connection with the performance of his work.

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 General

Loading tests shall be carried out on erected structures, if required by the Engineer, to check adequacy of fabrication and/or erection. Any structure or a part thereof found to be unsuitable for acceptance as a result of the test shall have to be dismantled and replaced with suitable member as per the Contract and no payment towards the cost of the dismantled portion and any connected work shall be made to the contractor. In course of dismantling, if any damage is done to any other parts of the structure or to any fixtures, the same shall be made good free of cost by the Contractor, to the satisfaction of the Engineer. The Cost of the tests specified hereinafter shall be borne by the Owner; but if the structure fails to pass the tests, the cost of the tests shall be recovered from the Contractor. Any extra claim due to loss of time, idle labour, etc. arising out of these testing operations shall not be entertained, however, only reasonable

and appropriate time extensions will be allowed.

The structure or structural member under consideration shall be loaded with its actual dead load for as long a time as possible before testing and the tests shall be conducted as indicated in the following sub-clauses 4.01.01, 4.01.02 and 4.01.03. The method of testing and application of loading shall be as approved by the Engineer.

4.01.01 Stiffness Test

In this test, the structure or member shall be subjected, addition to its actual dead load, to a test load equal to 1.5 times the specified superimposed load, and this loading shall be maintained for 24 hours. The maximum deflection attained during the test shall be within the permissible limit. If, after removal of the test load, the member or structure does not show a recovery of at least 80 per cent of the maximum strain or deflection shown during 24 hours under load, the test shall be repeated. The structure or member shall be considered to have sufficient stiffness, provided that the recovery after this second test is not less than 90 per cent of the maximum increase in strain or deflection recorded during the second test.

4.01.02 Strength Test

The structure or structural member under consideration shall be subjected, in addition to its actual dead load, to a test load equal to the sum of the dead load and twice the specified superimposed load, and this load shall be maintained for 24 hours.

In the case of wind load, a load corresponding to twice the specified wind load shall be applied and maintained for 24 hours, either with or without the vertical test load for more severe condition in the member under consideration or the structure as a whole. Complete tests under both conditions may be necessary to verify the strength of the structure. The structure shall be deemed to have adequate strength if, during the test, no part fails and if on the removal of the test load, the structure shows a recovery of at least 20 per cent of the maximum deflection or strain recorded during the 24 hours under load.

4.01.03 Structure of same design

Where several structures are built to the same design and it is considered unnecessary to test all of them, one structure, as a prototype, shall be fully tested, as described in previous Sub-clauses, but in addition, during the first application of the test load, particular note shall be taken of the strain or deflection when the test load 1.5 times the specified superimposed load has been maintained for 24 hours. This information is required as a basis of comparison in any check test carried out on samples of the structure.

When a structure of the same type is selected for a check test, it shall be subjected, in addition to its actual dead load, to a superimposed test load, equal to 1.5 time the specified live load, in a manner and to an extent prescribed by the Engineer. This load shall be maintained for 24 hours, during which time, the maximum deflection shall be recorded. The check test shall be considered satisfactory, provided that the maximum strain or deflection recorded in the check test does not exceed by more than 20% of the maximum strain or deflection recorded at similar load in the test on the prototype.

4.01.04 Repair for subsequent test and use after strength tests

An actual structure which has passed the "Strength Test" as specified in Sub-clause 4.1.2 hereinbefore and is subsequently to be erected for use, shall be considered satisfactory for use after it has been strengthened by replacing any distorted members and has subsequently satisfied the 'Stiffness Test' as specified in Sub-clause 4.01.01 hereinbefore.

4.02.00 Tolerances

Some variation is to be expected in the finished dimensions of structural steel frames. Unless otherwise specified, such variations are deemed to be within the limits of good practice when they are not in excess of the cumulative effect of detailed erection clearances, fabricating tolerances for the finished parts and the rolling tolerances for the profile dimensions permitted under the Specifications for fabrication of structural steel work applicable to this Project and as specified below: The specified tolerance is mainly for welded erection. In case of bolted erection, no tolerance is desired so that all prefabricated bolt holes are matched on erection.

I. For Buildings Containing Cranes

Component	Description	Variation Allowed
1.	2.	3.
Main columns	a) shifting of column axis at foundation level with respect to building line	
	i) In longitudinal direction	i) ± 3.0 mm
	ii) In lateral direction	ii) ± 3.0 mm
	b) Deviation of both major column axis from vertical between foundation and	

	other member connection levels:	
	i) For a column upto and including 10M height	i) ± 3.5 mm from true vertical
	ii) For a column greater than 10M but less than 40M height	ii) ± 3.5 mm from true vertical for any 10 M length measured between connection levels, but not more than ±7 mm per 30m length.
	c) For adjacent pairs of columns across the width of the building prior to placing of truss	± 9.0 mm on true span.
	d) For any individual column deviation of any bearing or resting level from levels shown on drawings.	± 3.0 mm
	e) For adjacent pairs of columns either across the width of building or longitudinally level difference allowed between bearing or seating	3.0 mm
Trusses	a) Deviation at centre of span of upper chord member from vertical plane running through centre of bottom chord.	1/1500 of the span or greater than 10mm whichever is the least.
Trusses	b) Lateral displacement of top chord at center of span from vertical plane running through center of supports.	1/250 of depth of truss or 20 mm which ever is the - least.
Crane Cirders	a) Difference in levels of crane rail measured between adjacent columns.	2.0 mm.
	b) Deviation to crane rail-gauge	± 3.0 mm

	c) Relative shifting of ends of adjacent crane rail in plan and elevation after thermite welding.	1.0 mm.
	d) Deviation of crane rail axis from centre line of web.	± 3.5 mm
Setting of Expansion gaps	At the time of setting of the expansion gaps, due regard shall be taken of the ambient temperature above or below 30°C. The coefficient of expansion or contraction shall be taken as 0.000012 per °C per unit length.	

iv) For Building without Cranes

The maximum tolerances for line and level of the steel work shall be ±3.0 mm on any part of the structure. The structure shall not be Out of Plumb more than 3.5 mm on each lox section of height and not more than 7.0 mm per 30 m section.

These tolerances shall apply to all parts of the structure unless the drawings issued for erection purposes state otherwise.

4.03.00 Acceptance

Structures and members have passed the tests and conform to all requirements specified in the foregoing Sub-clause 4.01.00, 4.01.01, 4.01.02, 4.01.03 and 4.01.04 and other applicable provisions of this specification and are within the limits of tolerances specified in Sub-clause 4.02.00 and/or otherwise approved by the Engineer shall be treated as approved and accepted for the purpose of fulfillment of the provisions of this contract.

5.00.00 INFORMATION TO BE SUBMITTED

5.01.00 Before Tender

5.01.01 Tentative Programme

The Tenderer shall submit a tentative programme based on the information available in the Tender Document and visit to site indicating the structure-wise erection schedule proposed to be maintained by the Contractor to complete the job in time in accordance with the Contract.

5.01.02 Constructional Plant and Equipment, Tools, Temporary works & manpower A detailed list of all constructional plant and equipment like cranes, derricks, winches, welding sets, erection tools etc. along with their make, model, present condition and location available with the Tenderer which he will be able to employ on the job to maintain the progress of work in accordance with the Contract shall be submitted along with the Tender. The total number of each category of experienced personnel like fitters, welders, riggers etc. that he will be able to employ on the job shall also be indicated.

5.01.03 Erection Yard

A site plan showing the layout and location of the erection yard proposed to be established by the tenderer shall also be attached with the tender indicating the storage space for fabricated steel materials, site-fabrication and repair shop, covered stores, offices, locations of erection equipments and other facilities. The Engineer shall have the right to modify the arrangement and location of the proposed yard to suit site conditions and the Contractor shall comply with the same without any claim whatsoever.

5.02.00 After award of the Contract

After award of the contract, the Contractor shall submit the following:

5.02.01 Detailed Programme

The Contractor shall submit a detailed erection programme within a month of the award of the Contract for completion of the work in time in accordance with the Contract. This will show the target programme, with details of erection proposed to be carried out in each fortnight, details of major equipment required, and an assessment of required strength of various categories of workers in a proforma approved by the Engineer.

5.02.02 Fortnightly Progress Report

The Contractor shall submit fortnightly progress reports in triplicate to the Engineer showing along with necessary photographs, 125 mm x 90 mm size, and all details of actual achievements against the target programme specified in Sub-clause 5.02.01 above. Any shortfall in the achievement in a particular fortnight must be made up within the next fortnight. Along with this report, the Contractor shall also furnish details of fabricated materials in hand at site and the strength of his workers.

VOLUME: II B

SECTION - D

SUB-SECTION – D19

ROOF DECKING

SPECIFICATION NO. PE-TS-999-600-C019

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
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6.00.00	RATES AND MEASUREMENTS	7

ROOF DECKING

1.00.00 Scope

This section of the specification covers the supply, fabrication and erection of profiled light gauge Metal Decks (coated and painted) as roof decking to the main plant building and any other area as indicated in the drawings.

2.00.00 Material

2.01.01 Roof of main plant TG and Deaerator bay and bunker building consists of permanently colour coated (on exposed face) galvanized MS trough metal sheet decking plate of approved colour over roof purlins for cast-in-situ roof slab as per IS: 14246 and conform to class 3. Thickness of deck plate shall be minimum 0.8mm and minimum trough depth of 44 mm and center to center of the valley shall be 130mm with minimum yield strength of 250 Mpa. Silicon modified polyester paint shall be used for permanent coating over galvanized surface with minimum rate of galvanization 150 gm/sqm. DFT of permanent colour coating shall be 20 microns. It shall serve as permanent shuttering for cast-in-situ roof slab. It should have adequate strength to support weight of green concrete and imposed load during construction. The thickness of the deck plate shall however be designed suitably according to the spacing of roof purlins.

3.00.00 INSTALLATION

The Contractor shall furnish all labour, equipment and materials as required for the design, fabrication, coating, erection and fixing of the decking over purlins, painting and for the complete performance of the work in accordance with the construction drawings and as described herein.

The description, which follows, gives a general indication of the nature and extent of the work but is not necessarily exhaustive and does not purport to cover all the details/operations which will be necessary in order to carry out the work.

3.01.00 Detailed Design of Roof Decking

The Contractor, in conjunction with the manufacturer, shall be responsible for the detailing of the profiled decking, fittings and fixtures and shall submit with his tender particulars of the proposed manufacturer and of the particular product proposed for use. The detailing is to be based on typical details furnished by the Engineer. The Contractor shall submit to the Engineer, two copies of the general arrangement and detailed working drawings for the proposed design, together with all calculations necessary to verify the adequacy and completeness of the design & detailing of decking sheets, fixtures, flashings and trims. After approval he shall supply further eight copies.

The Engineer will verify the correct interpretation of his requirements but may not necessarily check the design and details, and the Contractor shall be entirely responsible for the accuracy of the drawings and the correctness of the design and the suitability of the details. Manufacture of roof decking sheets shall not commence until the necessary approval of the Engineer has been obtained.

3.02.00 Erection & Fixing

3.02.01 Sequence of Manufacture/Erection

Cutting Schedules, delivery to site and stacking arrangements in store shall ensure that sheets are erected in a sequence which follows that for the manufacture. The decking sheets shall be erected using an arrangement of sheets and joints to conform with the requirements of this specification. Decking erection for each elevation or feature shall commence at one end only and proceed towards the other end, in order to ensure tight fitting laps.

3.02.02 Position and Location of Laps

Side and end laps of roof decking sheets shall be located and positioned in such a manner as to provide the maximum weather protection taking into account the direction of the prevailing wind.

The lines formed by horizontal laps and fixing shall where possible, be continuous and coincide with the edges of large openings in the roof.

3.02.03 Alignment of Sheets and Fixings

All roof decking sheets shall be fixed plumb and level with all fixings evenly spaced and accurately lined. All dirt and grease shall be removed from the surfaces of the sheets as the work proceeds.

3.02.04 Site Cutting

Approval must be obtained before the roof decking sheets are cut at site. Generally cutting of sheets to length will not be permitted, only special cutting and trimming for small openings shall allowed. Where possible, site cut edges shall be concealed at laps.

3.02.05 Damaged Sheets

Distorted, blemished or water stained sheets and any other fittings shall not be used.

3.02.06 Laps

End laps and side laps to roof decking sheets shall be sufficiently large to ensure that the decking complies with the weather tightness and other requirements of this specification. The length of each decking sheet shall be adjusted so that the end laps shall bear on the purlins. In no case end laps shall not be less than 150 mm and side laps shall not be less than 53 mm.

3.02.07 End Lap Fixings

End lap fixings shall be located at least 25 mm from the end of each sheet.

3.02.08 Side Lap Fixings

The spacing of side lap fixings shall ensure compliance with this specification regarding tightness. The spacing of these fixing screws shall not exceed 500mm. The fixing shall be located in the bottom flat of the corrugation.

3.02.09 Holes

Holes in MS decking sheets shall be punched. In case holes are drilled holes, it is to be ensured that the holes do not go oversize due to the small thickness of the sheeting. All drilling swarf shall be removed from the surfaces of decking, supporting steel work, purlins etc.

3.02.10 Location and Spacing of Fixings

Fixings shall be accurately located in position in the centre of the corrugations to ensure that the heads of bolts, nuts and washers bear squarely down on the surface of the sheeting and are not located at the edge or on the joints in supporting purlins.

3.02.11 Fixings

The tenderer shall submit with his tender details of the proposed method for securing the roofing sheets to the metal purlins. The roof decking sheets are to be fixed to the roof purlins with hex washer head white zinc plated heat treated carbon steel self-drilling / self-tapping screws of minimum thread diameter of 5.6mm. These self-drilling screws shall be drilled through the roofing sheets and purlins supporting the roofing sheets. These purlins shall be suitably spaced as per the requirement of roofing sheets and the roofing sheets shall not sag more than span/250 for the loads likely to be imposed during concreting and in future. The self-drilling screws are to be spaced at a maximum distance of 390mm centre to centre along the length of the purlins and top chord of truss. The screws are to be located preferably in the valley only and shall be installed in accordance with the manufacturer's

recommendations using tools approved by the manufacturer which do not damage the coating of the decking sheets.

3.03.00 Protection during Construction

Precautions shall be taken during the erection of the roof decking to ensure that partially erected decking are protected during inclement weather and damage at all times.

3.04.00 Damage

Any damage to coating & primer during transportation is to redone with the similar type of coating as per the manufacturer's specification at no extra cost to the Owner.

4.00.00 Acceptance Criteria

The installation shall present a neat appearance and shall be checked for water tightness. The following shall be checked:

a) Side and end laps

b) Absence of damage in the sheeting.

c) Conformity of fixings with the approved design.

5.00.00 IS Codes

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

IS: 513 - Specification for cold rolled carbon steel sheets.

IS: 3618 - Specification for phosphate treatment of iron and steel for protection against corrosion.

IS: 4431 - Specification for carbon & carbon manganese free cutting steel.

IS: 1573 - Electroplated Coatings of zinc on iron and steel.

6.00.0 RATES AND MEASUREMENTS

6.01.00 Rates

Rates shall be unit rate for complete item described in the Schedule of Items and shall include all wastage.

6.02.00 Method of Measurement

Roofing shall be measured for net area of the work done. Profiled sheeting (coated & painted) shall be measured in plan area of sheets and not girthed. No deduction shall be made for openings measuring up to 0.1 sq.m. in area. No extra shall be paid for extra labour in cutting and for wastage etc. in making opening and cutting to size.

No payments shall be made for laps.

VOLUME: II B

SECTION - D

SUB-SECTION – D20

FALSE FLOORING

SPECIFICATION NO. PE-TS-999-600-C020

Maharatna Company

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

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FALSE FLOORING

1.00.00 General

This section of the specification covers the supply, fabrication and installation of false flooring system having PVC top finish particle board, GI supporting system, painting etc. as per schedule of items in the main plant building and any other area as indicated in the drawings.

The scope of contractor covers supplies of all materials, fabrication & installation works required to be carried out for completion of false flooring in the area specified in the drawings.

2.00.00 MATERIAL

2.01.00 Supporting structure

Supporting pedestals shall be made of steel and will be of height as required. Supporting pedestal shall be truly vertical and located at distances to conform with size of floor panels and shall be equipped with locking devices to prevent disturbances of finished elevation. Base of pedestal shall have integral load dispersion plate of size 100x100x8mm to transmit the load evenly to the base floor. Adjustment of pedestal shall be provided by threaded vertical rod of 25mm diameter and elevating nut. The pedestal head shall provide positive interlocking of the steel grid channels supporting system and shall prevent lateral shifting.

The grid channels shall be made of galvanised steel of 40mm x 40mm x 3.15mm thick and shall be placed at 610mm centre to centre both ways to support floor panels in uniform levelled elevations. Nominal height of the false flooring system shall be 600 mm unless otherwise indicated. Pedestal head shall be equipped with conducting grounding pad if so desired by the Engineer

2.02.00 Floor Panels

The floor panels shall be made of fire resistant particle board, phenol formaldehyde bonded. Size of each panel shall be 610mm x 610mm with all panel edges finished to a tolerance of + 0.2mm. Floor panel shall have 2mm thick non-static PVC on top, 2mm thick hard PVC strip lipping on four edges and 26 G aluminium sheet fixed with araldite at bottom. Minimum thickness of the panel shall be 35mm, unless otherwise noted. All panels shall be completely interchangeable and easily removable with a suction lift tool. Panels shall be square within a tolerance of $\pm$ 0.25 mm on the diagonal. The floor panels shall be cut, wherever required for providing suitable outlets for cables and edges shall be lipped with hard PVC sheets.

2.02.01 Strength

Each 610mm x 610 mm floor panel must be capable of withstanding the designed service load. The ultimate strength shall provide a safety factor of 3. The false flooring shall be capable of carrying a axial load of 800 kg and uniform load of 2000 kg/sq.m with maximum deflection of 1/350. If required by the Engineer, the samples shall be accepted only after carrying out load tests. The Engineer may relax the test requirements with concentrated load in case cabinets are not handled with castor fitting arrangement.

One additional pedestal shall be provided under floor stringer along front panel area of each control board for taking possible additional load that may occur from time to time.

2.02.02 Surface finish

All removable panels shall have the top surface finished with 2 mm thick flexible PVC flooring conforming to IS:3462 and shall be fixed to the surface with compatible high-creep resistant adhesive. The PVC floor tile shall be in single piece for each floor panel. Under side of panels shall also be painted with suitable epoxy or oil based paint.

2.02.03 Damaged Floor Panels

Distorted, blemished or stained floor panels shall not be used.

2.03.00 Skirting

Skirting shall be 150 mm high and 2 mm thick, completely matching with false flooring surface finish materials and shall be fixed to the wall surface as per manufacturer’s installation instructions.

3.00.00 INSTALLATION

3.01.00 Base

The system shall be placed over a base of RCC floor slab and beams. Any grouting etc. that is necessary to fix the supporting structure shall be done.

The concrete sub floor shall be sealed with two coats of polyurethane paint to prevent moisture from coming in contact with cables and to minimize dust problem.

The floor panels and channels shall be completely interchangeable and remain in position without screwing or bolting under working/imposed loadings.

Any damage to the sub floor during installation of the false flooring system

shall be made good by the contractor without any extra cost to the Owner. All steel surfaces are to be protected by two coats of polyurethane paint over a compatible primer and any damage to the paint during installation shall be made good. In case the loads exerted by the weight of machines are above the stated characteristics of floor finish material, the floor shall be protected by overlaying hard board during installation of machine or equipment.

All installation work of the false flooring system shall be supervised by the manufacturer's authorized representative.

3.03.00 Painting

After fixing the false flooring supporting system the sub floor shall be given a coat of polyurethane paint.

3.04.00 Protection during Construction

All precautions shall be taken during the erection of the false flooring to ensure that partially erected flooring are protected and shall not be damaged before handing over to owner.

3.05.00 Damage

Any damage of coating to supporting system caused during transportation is to be redone with the similar type of coating as per the manufacturer’s specification at no extra cost to the Owner.

4.00.00 ACCEPTANCE CRITERIA

The false flooring system shall only be accepted after completion of following checks:

a. Level

b. Alignment of joints

c. Thickness of joints

d. Surface finish

e. Colour and texture

f. Details of edges, junctions etc.

g. Performance

h. Criteria specified for strength.

5.00.00 IS CODES

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

IS:5318 Laying of flexible sheet and flooring.

IS:3462 Flexible PVC flooring

IS:3087 Wood particle boards (medium density) for general purposes.

6.00.0 RATES AND MEASUREMENTS

6.01.00 Rates

Rates shall be unit rate for complete item described in the Schedule of Items and shall include, but not limited to, supply & installation of floor panels, supporting systems, paintings etc.

6.02.00 Method of Measurement

False flooring shall be measured in Sq.M for net area of the work done. No deduction shall be made for openings measuring up to 0.4 sq.m. in area. No extra shall be paid for extra labour in cutting and for wastage etc. in making opening and cutting to size.

VOLUME: II B

SECTION - D

SUB-SECTION – D21

BORED CAST-IN-SITU RCC PILES

SPECIFICATION NO. PE-TS-999-600-C021

Maharatna Company

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

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TECHNICAL SPECIFICATION FOR INSTALLATION OF BORED CAST-IN-SITU PILES

1.00.00 SCOPE

This specification covers the installation of bored cast-in-situ reinforced concrete vertical piles of specified load carrying capacity and diameter for various structures. This specification also covers carrying out initial and routine load tests on piles to assess their vertical, horizontal and pull out load carrying capacities.

2.00.00 GENERAL REQUIREMENTS

2.01.00 This specification along with specific requirements under Annexure-A covers the technical requirements for piling work.

2.02.00 The work shall include supplying and providing necessary materials, mobilization of all necessary equipments (Annexure-B), providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labour, etc. as required to carry out the complete piling work, and submission of records as per schedule.

2.03.00 The Contractor shall carryout all works as mentioned in Scope above. All works shall be executed to the satisfaction of the Engineer.

2.04.00 Pile capacities in vertical compression, horizontal, pull-out loads for various pile diameters are given in Annexure-A.

2.05.00 The Contractor shall confirm and guarantee the "Safe Load" capacities by conducting both initial and working load test on piles as mentioned in the specific requirements.

2.06.00 The Contractor shall submit along with tender documents his tender design of piles based on soil data furnished by the Owner along with this specification. The ultimate load capacity of a pile may be estimated using suitable static formula and the minimum factor of safety shall be 2.5. However, safe load carrying capacity shall be conformed and guaranteed by conducting initial and routine load tests.

2.07.00 In case of initial or routine load test piles, if the Contractor fails to establish the safe load capacity as per his design, the Owner has the right to either derate the pile capacity on prorata basis or insist the Contractor to modify the pile design, to achieve the desired safe load capacity at no extra cost to the Owner.

2.08.00 Derating is acceptable up to 90 percent. In such case, additional piles shall be installed as per the design requirements.

2.09.00 The Owner shall decide whether to derate or modify the design based on the design considerations such as providing additional piles in the designed pile cap, provision for extending the pile cap size, etc.

2.10.00 In case the Owner decides to modify the design instead of derating the pile, the contractor shall carry out the same and install separate test piles and test the same to guarantee the safe load at no extra cost to the Owner. However, no extra shall be charged for the additional test piles as well as testing of these piles as per agreed contract conditions.

2.11.00 In case of working piles, if the pile does not meet the guaranteed capacity or rejected due to any other reason, the Contractor shall install extra piles at no extra cost to the Owner. Further, the extra cost, due to the increase in the pile cap size if any, on account of extra piles, shall be borne by the Contractor.

2.12.00 It is essential that all equipment and instruments are properly calibrated both at commencement and immediately after the completion of tests so that they represent true values. Certificates to this effect from an approved institution shall be furnished to the Engineer. If the Engineer so desires the Contractor shall arrange for having the instruments tested at an approved laboratory at no extra cost to the Owner and the test report shall be submitted to the Engineer. If the Engineer desires to witness such tests Contractor shall arrange to conduct the test in his presence.

2.13.00 The Contractor shall make his own arrangements for locating the coordinates and position of piles as per drawings supplied to him and for determining the Reduced Levels (RL) of these locations with respect to the benchmark indicated by the Engineer. Two established reference lines in mutually perpendicular direction shall be indicated to the Contractor. The Contractor shall provide at site all the required survey instruments to the satisfaction of the Engineer so that the work can be carried out accurately according to specifications and drawings.

2.14.00 The contractor shall assure the quality of piling work including cleaning of pile bore, quality of concrete, integrity of piles, etc.

2.15.00 **AVAILABLE SUB-SOIL DATA**

An abstract of the sub soil data is furnished in the tender document. However, the detailed soil investigation report shall be made available for reference of the bidder, if so required, at the office of the Owner. The soil data furnished is in good faith and only for the guidance of the Bidder, to arrive at design parameters and construction methods.

3.00.00 MATERIALS

3.01.00 General

All materials viz cement, steel, aggregates, water, etc. which are to be used for pile construction shall conform to relevant IS codes for properties, storage and handling of common building materials. However, aggregates more than 20 mm size shall not be used.

3.02.00 CONCRETE

Concrete shall be manufactured either by central batching plant or Ready Mix concrete. However, for initial test piles suitable method as approved by the Engineer may be used. Concrete shall conform to IS: 10262 & IS: 456.

3.02.01 Technical Specification for Cement Concrete (Plain and Reinforced) works along with IS: 2911 Part I/Sec 2 shall be followed for concrete works of piles. Use of plasticiser to control the water cement ratio shall be permitted on specific approval from the Engineer. Water cement ratio shall not be greater than 0.5.

3.02.02 Grade and minimum cement content
Minimum grade of concrete shall be as per Annexure-A conforming to IS: 456. Minimum cement content of 400 Kg/M³ of concrete shall be used for M-20 grade concrete.

3.02.03 Slump of concrete
The slump of concrete shall vary between 150 to 180 mm.

3.03.00 REINFORCEMENT

3.03.01 Longitudinal reinforcement in pile shall be high strength deformed steel bars conforming to IS: 1786 unless specified otherwise. Lateral reinforcement in pile shall be of mild steel conforming to IS: 432 Part-1 or HYSD bars as per IS: 1786.

3.03.02 The longitudinal reinforcement shall be provided considering the combination of vertical (compression and tension) and horizontal loads. However, the minimum longitudinal reinforcement shall be 0.4 percent of the sectional area calculated on the basis of nominal pile diameter. Minimum six numbers of bars shall be provided for longitudinal reinforcement. The diameter of longitudinal reinforcement bars shall not be less than 12mm. The stipulated minimum reinforcement shall be provided for the full length of pile.

3.03.03 The longitudinal reinforcement shall project 50 times its diameter above cut off level unless otherwise indicated.

3.03.04 The laterals shall be tied to the longitudinal reinforcement to maintain its shape and spacing. The laterals may in the form of links or spirals. The minimum diameter of the links or spirals shall be 6 mm and the spacing of the links or spiral shall not be less than 150 mm and in no case more than 250 mm.

3.03.05 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment, these shall preferably be assembled before lowering into casing tube/pilebore by providing necessary laps as per IS: 456.

3.03.06 The minimum clear distance between the two adjacent main reinforcement bars shall normally be 100 mm for the full depth of cage.

3.03.07 The laps in the reinforcement shall be such that the full strength of the bar is effective across the joint and the reinforcement cage is of sound construction.

3.03.08 Laps shall be staggered as far as practicable and not more than 50% bars shall be lapped at a 'particular section. Lap joints shall be staggered by at least 1.3 times the lapped length (Centre to Centre).

3.03.09 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers, cast specifically for the purpose.

3.03.10 Minimum clear cover to the longitudinal reinforcement shall be 50 mm, unless otherwise mentioned.

3.03.11 Bundling of bars is not permitted.

4.00.00 PILE INSTALLATION

Installation of piles shall be carried out as per pile layout drawings, installation criteria, and the direction of the Engineer.

4.01.00 Equipment and Accessories

4.01.01 The equipment and accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub soil conditions, ground water conditions and the method of casting, etc. These shall be of standard type and shall have the approval of the Engineer.

4.01.02 List and details of equipment and accessories proposed to be used for the job shall be submitted along with the bid.

4.01.03 The capacity of the rig shall be adequate so as to reach the specified founding level.

4.01.04 Provision shall be kept for chiselling within the pilebore, as specified elsewhere in this specification. Chiselling shall be carried out only with the approval of Engineer.

4.02.00 Installation Criteria

4.02.01 For determining the founding level of piles in soil as specified elsewhere, the Contractor shall have to perform Standard penetration test (SPT) as per IS: 2131 in a separate bore hole. The SPT shall be conducted at 1.0 m interval between the depths covering 5 metres each above and below the specified founding level. The bore shall be 100 mm diameter and method of boring shall conform to IS: 1892.

4.02.02 For determining founding level of piles in rock, as specified elsewhere socketing horizon shall be established by the Contractor by collecting rock cores of NX size in a separate borehole, and testing the same for uniaxial compressive strength (UCS). Cores shall be collected by double tube core barrel attached with diamond bit. Coring shall be done upto a depth as indicated in the "specific requirements." Coring in rock shall conform to IS: 6926.

4.02.03 In case it is not possible to test the cores so obtained for uniaxial compressive strength, cores shall be tested for point load strength index and correlated to obtain uniaxial compressive strength.

4.02.04 Number of boreholes for carrying out SPT in soil or uniaxial compressive strength in rock, shall vary from one in 100 to 150 piles or pile group of 150 Sqm depending on the site condition and as decided by the Engineer. However, at the location of initial load test piles, one such borehole shall be done.

4.02.05 A protocol between contractor and BHEL site shall be maintained regarding the strata at founding level. SPT value and UCS from the nearest borehole shall be indicated therein.

4.02.06 The founding level of the pile shall be decided based on the criteria elaborated in the specific requirements under Annexure-A. Concreting shall not be done until the above conditions for founding level are satisfied.

4.02.07 Approval of founding level by the Engineer shall in no way absolve the Contractor of his responsibility to guarantee the Safe load capacity of the piles as indicated in this document.

4.03.00 Control of position and alignment

4.03.01 Piles shall be installed as accurately vertical as possible. The permissible limits for deviation with respect to position and (inclination) alignment shall conform to IS: 2911 Part I/Sec. 2, which is reproduced below for ready reference.

a) The maximum deviation of vertical piles shall not exceed 1.5 per cent in alignment.

b) Piles shall not deviate more than 75 mm or D/4 whichever is less (75mm or D/10 whichever is more in case of piles having diameter more then 750mm) from their designed position at the working level.

4.04.00 Boring

4.04.01 Boring operations shall be done by rotary or percussion type drilling rigs using reverse mud circulation (RMC) method. Rotary hydraulic pulley shall be preferred.

4.04.02 The Contractor shall satisfy himself about the suitability of the method to be adopted for site. If DMC (direct mud circulation) or RMC is used Bentonite slurry shall be pumped through drill rods by means of high-pressure pumps. The cutting tool shall have suitable ports for the bentonite slurry to flow out at high pressure. If on mobilisation, the Contractor fails to make a proper bore for any reason, the Contractor has to switchover to other boring methods as approved by the Engineer at no extra cost to the Owner.

4.04.03 Working level shall be above the cut off level. After the initial boring of about 1.0m a temporary guide casing of suitable length shall be lowered in the pile bore. The diameter of guide casing shall be of such diameter, so as to give the necessary finished diameter of the concrete pile. The centre line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum of 1.0m length. Additional length of casing may be used depending on the condition of the strata, ground water level etc.

4.04.04 Use of drilling mud (bentonite slurry) for stabilizing the sides of the pile bore is necessary wherever subsoil is likely to collapse in the pile bore. Drilling mud to be used shall meet the requirement as given in Annexure-C.

4.04.05 The bentonite slurry and the cuttings, which are carried to the surface by the rising flow of the slurry, shall pass through settling tanks of adequate size to remove the sand and spoils from the slurry before the slurry is recirculated to the boring. The bentonite slurry mixing and recirculation plant shall be suitably designed and installed.

4.04.06 The bentonite slurry shall be maintained at 1.5m above the ground water level during boring operations and till the pile is concreted. When DMC or RMC

method is used the bentonite slurry shall be under constant circulation till start of concreting.

4.04.07 The size of cutting tools shall not be less than the diameter of the pile by more than 75mm. However, the pile bore shall be of the specified size.

4.05.00 Chiselling

4.05.01 Chiselling may be resorted to with the permission of the Engineer below the socketing horizon. The chiselling tool or bit shall be of adequate size and weight so as to reach the desired depth.

4.06.00 Cleaning of Pile bore

4.06.01 On completion of the pile bore upto the required depth, the bottom of the hole shall be cleaned very carefully before concreting work is taken up. Cleaning shall ensure that the pile bore is completely free from sludge/bored materials, debris of rock/boulder etc. Necessary checks shall be made as given in clause 5.0 to confirm the thorough cleaning of the pile bore.

4.06.02 Pile bore shall be cleaned by fresh drilling mud through tremie pipe after placing reinforcement and just before start of concreting.

4.06.03 Pile bore spoil along with used drilling mud shall be disposed off from site as directed by the Engineer.

4.06.04 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.

4.07.00 Adjacent Structures

4.07.01 When working near existing structures care shall be taken to avoid any damage to such structures.

4.08.00 Concreting

4.08.01 The Contractor shall carry out concrete mix design in accordance with IS: 10262 and submit mix design calculations and get them approved from the Engineer well in advance for installation of piles. Adequate number of tests on cubes, etc. shall be carried out as mentioned in clause 5.0 to ensure concrete of the minimum specified strength in accordance with IS: 456 at requisite workability (slump).

4.08.02 Concreting shall not be done until the Engineer is satisfied that the bearing strata (soil/rock) met with at the termination level of pile.

4.08.03 The time interval between the completion of boring and placing of concrete shall not exceed 6 hrs. In case the time interval exceeds 6 hrs the pilebore shall be abandoned. However, the Engineer may allow concreting provided the Contractor extends the pile bore by 0.5 m beyond the proposed depth, and clean the pilebore. The entire cost of all operation and materials for this extra length shall be borne by the Contractor.

4.08.04 Proper placement of the reinforcement cage to its full length shall be ensured before concreting.

4.08.05 Concreting shall be done by tremie method as specified by IS: 2911 (Part I /Sec.2). The level of drilling mud shall be maintained sufficiently above the ground water level.

4.08.06 The concreting operations shall not be taken up when the specific gravity of bottom slurry is more than 1.2 and sand content more than 7%. The drilling mud sample shall be collected from the bottom of pilebore as mentioned in clause 5.

4.08.07 Consistency of the drilling mud suspension shall be controlled throughout the concreting operations in order to keep the bore stabilized as well as to prevent concrete getting mixed up with the thicker suspension of the mud.

4.08.08 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.

4.08.09 The temporary guide casing shall be withdrawn cautiously, after concreting is done upto the required level. While withdrawing the casing concrete shall not be disturbed.

4.09.00 Cut off level (COL)

4.09.01 Cut off level of piles shall be as indicated in drawings released for construction or as indicated by the Engineer.

4.09.02 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment in to pile cap.

4.09.03 When the pile cut off level is less than 1.0 metre below the working level, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 metre below working level then concrete shall be cast to a minimum of one metre above COL.

4.10.00 Sequence of Piling

4.10.01 Each pile shall be identified with a reference number.

4.10.02 The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.

4.11.00 Building up of Piles

4.11.01 If any pile, already cast as per construction drawing, requires any extra casting due to any change in cut off level or the cast pile top level is less than the specified level or for any other reason, then the pile shall be built-up by using atleast one grade higher concrete than that used for concreting of the same pile, ensuring proper continuity with the existing concrete and to the satisfaction of the Engineer. Necessary reinforcement as per design requirement and suitable shuttering shall be provided before casting the concrete. Surrounding soil shall also be built up to the required level by proper compaction to ensure lateral capacity of the pile.

4.12.00 Breaking off of Piles

4.12.01 If any pile already cast, requires breaking due to lowering in cut off level or for any other reason, then the same shall be carried out, not before seven days of casting without affecting the quality of existing pile such as loosening, cracking etc. and to the satisfaction of the Engineer.

4.13.00 Preparation of Pile head

4.13.01 The soil surrounding the piles shall be excavated upto the bottom of the lean concrete below the pile cap, with provision for working space, sufficient enough to place shuttering, reinforcement, concreting and any other related operations.

4.13.02 The exposed part of concrete above the COL shall be removed/chipped off and made to a uniform level at COL, but not before seven days of casting of pile.

4.13.03 The projected reinforcement above COL shall be properly cleaned and bent to the required shape and level to be anchored into the pile cap.

4.13.04 The pile top shall be embedded into the pile cap by 50mm or clear cover to reinforcement, whichever is higher.

4.13.05 All loose material, like debris due to chipping/breaking of pile head to the desired level, shall be removed and disposed off as directed by the Engineer.

4.14.00 Rejection and Replacement of Defective Piles

4.14.01 The Engineer reserves the right to reject any pile which in his opinion is defective on account of load capacity, structural integrity, position, alignment, concrete quality etc. Piles that are defective shall be pulled out or left in place as judged convenient by the Engineer, without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the Engineer, at no extra cost to the Owner.

4.15.00 Recording of Piling Data

4.15.01 The Contractor shall record all the information during installation of piles. Typical data sheet for recording pile data shall be as shown in Appendix D of IS: 2911 Part I/Sec.2. The pile data shall also include all the details as in Annexure-D. On completion of each pile installation, pile record in triplicate shall be submitted to Engineer within two days of completion of concreting of the pile.

5.00.00 SAMPLING, TESTING AND QUALITY ASSURANCE

5.01.00 Facilities required for sampling and testing of materials, concrete, etc. in field and in laboratory should be provided by the Contractor. The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and this Specification. Where no specific testing procedure is mentioned the tests shall be carried out as per the prevalent accepted engineering practice and as per the directions of the Engineer. Tests shall be done in the presence of the Engineer or his authorized representative. In case the Engineer requires additional tests, the Contractor shall arrange to get these tests done and submit to the Engineer the test results in triplicate within three days after completion of any test.

5.02.00 The Contractor shall maintain records of all inspection and testing, which shall be made available to the Engineer. The Engineer at his discretion may waive some of the stipulations for small and unimportant concreting operations and other works.

5.03.00 Materials found unsuitable for acceptance shall be removed and replaced by the Contractor. The work done by this unsuitable material shell be redone as per specification requirements & and to the satisfaction of the Engineer at no extra cost to the Owner.

5.04.00 Quality Assurance Programme

a) The Contractor shall submit and finalize a detailed Field Quality Assurance Programme within 30 days from the date of award of the contract, according to the requirements of this specification. This shall include setting

up of a testing laboratory, arrangement of testing apparatus/equipment, deployment of qualified/experienced manpower, preparation of field quality plan, etc. On finalized field quality plan, the Owner shall identify, customer hold points, beyond which work shall not proceed without written approval from the Engineer. The testing apparatus/equipment installed in the field laboratory shall be calibrated/ corrected by the qualified persons as frequently as possible to give accurate testing results.

b) Frequency of sampling and testing, etc. and Acceptance Criteria are given in Table - 1. The testing shall be done at field laboratory or any other laboratory approved by the Engineer. However, the testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to call for tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications. The materials shall be tested to meet all the specified requirements before acceptance at manufacturers premises or at independent government approved laboratory. Tests indicated in the table are for cross checking at site the conformity of the materials to some of the specifications.

5.05.00 Testing of Concrete

5.05.01 Concrete and other materials shall be tested for quality, strength and other properties. Details of testing shall be as specified under technical specification for Cement concrete (Plain and Reinforced).

5.05.02 One sample consisting of six test cubes shall be made from the concrete used in each test pile, three to be tested after 7 days and three after 28 days.

5.05.03 For working piles, minimum one sample consisting of six test cubes shall be made from the concrete for the first ten piles, three to be tested after 7 days and three after 28 days. Thereafter, minimum one sample consisting of three test cubes for every 10 piles shall be tested for the 7-days & 28-days cube strength.

5.05.04 In preparation of test cubes or specimen's vibrators shall not be used.

5.05.05 Concrete shall be tested for slump at every 1-hour interval during concreting of piles.

5.05.06 The frequency of sampling and testing of concrete and materials shall be done as per technical specification for cement concrete (Plain & Reinforced).

5.05.07 The acceptance criteria shall be as mentioned in Table-1.

5.06.00 Testing for position and alignment

5.06.01 Each pile shall be checked for its position with respect to specified location. Each pile bore shall be checked for its alignment.

5.06.02 Permissible limits for deviation shall be as specified under clause no. 4.03.

5.07.00 Properties of Drilling mud

5.07.01 Properties of drilling mud shall be checked as per requirement under Annexure C. Prior to the commencement of piling work and thereafter minimum once in a week or as found necessary by the Engineer, one sample consisting of 3 specimens shall be tested. Acceptance criteria applicable are as specified elsewhere with 5% variation. This relaxation is not applicable for properties of drilling mud before concreting.

5.07.02 Density of the drilling mud shall be checked in each pile before concreting.

5.08.00 Check for Pile bore

5.08.01 On completion of boring and cleaning the bottom of each pilebore shall be checked from the sample collected from near the bottom of pile bore or by any other methods as approved by the Engineer, to ensure that it is free from pilebore spoil/debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Engineer.

5.08.02 For sampling of drilling mud from the pilebore the following method or any other suitable method shall be adopted.

a) A solid cone shall be lowered by a string to the bottom of pilebore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, and then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimize the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

b) Use of borehole camera for checking the pile bore spoil and strata is acceptable on approval of the Engineer.

5.09.00 Pile Integrity test

5.09.01 Low strain integrity test shall be conducted on 50% of the jobs piles and on all test piles or as directed by Engineer. The system shall have the computer readout facility and report on the findings of this shall be furnished to the Owner. This test shall be used to identify the job piles for routine load test.

Piles shall be trimmed to cut off level or sound concrete level. No pile cap blindage work should be undertaken prior to this test. The cast in-situ piles should not be tested before 14 days of casting.

5.09.02 The test shall be undertaken by persons trained and experienced and capable of interpreting the results with specific regard to piling. This test is limited to

testing the integrity of the shaft and is not intended to replace the use of static load testing.

5.09.03 Low Strain Integrity Test Methodology:

a) In this test, a low stress wave is set up in the pile shaft and is also known as Sonic Integrity or Sonic Echo test.

b) A small metal/hard rubber hammer is used to produce a light blow on top of the pile. The shock wave travelling down the length of the pile is reflected back from the toe of the pile and recorded through a suitable transducer/ accelerometer in a computer for subsequent analysis.

c) The primary shockwave, which travels down the length of the shaft, is reflected from the toe by the change in density between the concrete and sub strata. However, if the pile has any imperfections or discontinuities within its length these will set up secondary reflections, which will be added to the return signal.

d) By analysis of the captured signal and knowledge of the conditions of the ground, age of concrete, etc. a picture of the locations of pile shaft defects can be built up. The observed signals are amplified into digital display as velocity versus length records providing information on structural integrity of piles.

e) The stress wave velocity and approximate pile lengths are provided as input for the integrity testing. The stress wave velocity is dependent on the Young's Modulus and mass density of pile concrete.

f) More than one recording of signals shall be done until repeatability of signals is achieved on the same pile.

g) The tests shall be conducted at 3-6 locations to cover the entire cross section of the pile.

6.00.00 PILE TESTING

Pile load test shall be carried out as per IS:2911 Part-4 (latest edition) or as directed by Engineer.

6.01.00 INITIAL LOAD TEST

Initial load test shall be carried out on separately cast piles for confirmation of estimated pile capacities and to fix a more accurate driving criteria viz. set/bow, total number of blows and approximate depth etc. of founding level. At least 2 nos. of tests shall be conducted for each mode (vertical compression, pull out and lateral). The maximum test load shall be as

mentioned in bill of quantities.

6.02.00 ROUTINE LOAD TEST

Routine load tests shall be carried out on job (working) piles for 0.5% of total no. of piles (for each mode and type). Maximum test load shall be 1.5 times the design safe load capacity. Piles showing unsatisfactory results as per load test results shall be treated as defective piles. Defective piles shall be removed or left in place and replaced by additional piles as directed by Engineer at no extra cost to the owner. Any additional cost towards design implications, if any, due to above shall be borne by the contractor.

7.00.00 CODES AND STANDARDS

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

IS: 432 (Part 1 & 11)	-	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.
IS: 456	-	Code of practice for plain and reinforced concrete.
IS: 1200 (Part 23)	-	Measurement of Building and Civil Engineering works Piling.
IS: 1786	-	Code of practice for twisted steel high strength deformed bars for concrete reinforcement.
IS: 1892	-	Code of practice for Subsurface Investigation for foundation.
IS: 2131	-	Method of Standard Penetration Test for Soils
IS: 2911 Part I/Sec 2	-	Code of practice for design and construction of pile foundations - Bored cast-in-situ concrete piles.
IS: 2911 Part IV	-	Code of practice for design and construction of pile foundation - Load test on piles.
IS: 6926	-	Code of practice for Diamond Core Drilling for Site Investigation for River Valley Projects.
IS: 10262	-	Recommended guidelines for concrete mix design.

8.00.00 RATES AND MEASUREMENTS

The clauses below shall apply for item rate contracts only. They shall not be applicable to turnkey/lump sum Contracts.

8.01.00 Rates

8.01.01 The items of work in the schedule of items, describe the work in brief. The various items in schedule of items shall be read in conjunction with the corresponding sections in the Technical Specifications, including amendments, and additions, if any. For each item in schedule of items, the unit rate shall include for the activities covered in the description of the item as well as for all necessary operations described in the specification and specific requirements.

8.01.02 The unit rates shall include for minor details which are obviously and fairly intended, and which may not have been included in the description in these documents, but are essential for the satisfactory completion of the work. Unit rates shall also include for all safety measures as required by codal provisions, local regulations, acts, bye-laws, etc. and for execution of work to the satisfaction of the Engineer.

8.01.03 The quoted rate for each item shall be inclusive of mobilization of all plant, equipment, scaffolding, labour, materials, skilled and unskilled labour, and demobilization after completion of work, supervision, establishing the level and coordinates at each work.

8.01.04 The quoted rate for piling for a particular diameter and capacity of pile shall remain valid for the actual lengths provided /to be provided irrespective of the minimum length specified elsewhere in this specification.

8.01.05 The quoted rate for piling as per description of item works shall be inclusive of providing all plant equipment, labour, materials, skilled and unskilled labour, making observations, establishing the ground level and coordinates at each location of pile by carrying levels from one established bench mark and distances from one set of grid lines furnished by the owner.

8.01.06 The quoted rate for piling shall be inclusive of bailing out all the pile bore spoil from the pilebore, keeping the borehole free from bored material/debris etc. and disposing the bored/chiselled material along with the drilling mud upto 2 Km. beyond plant boundary or as directed by Engineer, flushing the pile bore by fresh bentonite before concreting, collection of samples from bottom of pilebore, transporting to laboratory, testing and reporting of results.

8.01.07 The quoted rate for piling shall include shifting of plant and equipment from one pile location to another pile location, providing temporary casing pipe and removal of the same after completing, concreting, supply of necessary materials,

equipment and manpower, cost of boring by approved method as specified, circulation of bentonite slurry and cleaning of borehole free from sludge, as specified, etc.

8.01.08 The quoted rate for piling shall also include chiselling, if any, required for socketing the pile in rock.

8.01.09 The quoted rate for the piling shall include concreting by termite method, length of pile above COL, withdrawal of guide casing, cost for preparation of pile head and disposal of debris etc., resulting from breaking off of pile upto COL, upto a distance of 2 Km from the plant boundary or as directed by Engineer.

8.01.10 The quoted rate for piling shall also include providing reinforcement and its cleaning, straightening, cutting, bending, binding with annealed wire, welding, tack welding, providing concrete cover blocks, spacers, placing the reinforcement cage in pile casing/bore and other cost of tools and plants, materials, labours, carting the steel from store to piling site and return of unused steel to the Owners storage point, etc.

8.02.11 Plasticiser/Admixture when used as directed by the Engineer shall be included in piling rates.

8.01.12 The quoted rate for piling shall include for all quality assurance requirements, but not limited to providing for technical inspection, transportation of samples to laboratory, testing samples, maintaining and submitting all test records, etc.

8.01.13 The quoted rate for boring in separate borehole shall be inclusive of performing of SPT at regular intervals as specified and collecting rock cores from boreholes, upto the depth as specified shall be inclusive of transporting to laboratory, testing and reporting of the results.

8.01.14 Unit rate for low integrity test shall be inclusive of mobilization of the entire set of equipment, computer readout, printer, and equipment which may not lave been included in the description but are essential for the satisfactory completion of the work as per internationally accepted practice. The rate quoted shall be inclusive of repeatability of test, preparation of pile top surface etc.

8.02.00 Measurement

8.02.01 Piling length shall be measurement by linear measurement from pile cut-off level to the tip of pile in meters upto second place of decimal separately for each diameter and capacity of pile. The length of pile to be cast above cut off level, as per specification, and as approved by Engineer, shall be considered for cement reconciliation only. Theoretical diameter of piles shall be

considered for reconciliation of cement consumption. No extra payment shall be made for the length from existing ground to cut-off level.

8.02.02 Reinforcement steel shall be measured for reconciliation purpose only and the measurement shall be done for providing and placing reinforcement in piles, by weight in tones, up to third place of decimal in the following manner:

i) The weight shall be arrived at by multiplying the actual length measured along with standard hooks, rings or spirals, spacers, cranks, bends, authorized laps, etc. by sectional weight. These shall be submitted with supporting documents giving the schedule of bars with sketches. The sectional weight to be adopted shall be IS code's sectional weight. Nothing extra shall be payable to the contractor on account of difference in weight, if any, due to different methods adopted for issue and measurement.

ii) Standard hooks, cranks, bend, authorized laps, supports, hangers and chairs which are covered in approved bar bending schedule shall be measured in tones.

iii) Dowels, neither shown on the drawings nor instructed by the Engineer, but required for construction facilities shall not be measured.

8.02.03 Breaking off of piles, due to subsequent change in design cut off level, shall be measured separately. This shall be measured in cubic metres upto second place of decimal. This will be payable only when the pile is cast and on the basis of written instruction of the Engineer for lowering of COL.

8.02.04 Measurements for the item of boring in a separate borehole shall be measured in metres from ground level upto the depth as specified, upto second place of decimal. Item of work of boring in soil and coring in rock shall be measured separately for the actual length of boring in soil and coring in rock.

8.02.05 The item for pile integrity test shall be measured in terms of no. of piles tested.

ANNEXURE-A

Specific Requirements for Bored Cast-in-situ RCC Piles

A1.0 Minimum cement concrete grade M-25

Minimum cement content 400 Kg/M³

A1.1 Safe load

Diameter of Pile

Diameter of Pile (mm)	Vertical/ Compression (MT)	**Horizontal/ Lateral (MX)**	**Pul lout/Tension (MT)**
*	*	*	*
*	*	*	*

A2. Installation criteria

The installed pile(s) shall satisfy the following criteria.

A2.1 In Soil/weathered Rock

a) Minimum length of the pile shall be _____* m below COL.

b) The pile shall be terminated after penetrating through the strata having SPT penetration less than __* cm for ____* blows, for a minimum length of _____* times the diameter of the pile.

A2.2 In Rock

a) Piles shall be installed and socketed into the rocks for a length (socketing length) equal to _____* times the pile diameter subject to a minimum of _____* meter below the socketing horizon.

b) Socketing horizon shall consist of rock strata having minimum uniaxial compressive strength of _____* kg/sq.cm.

A3. Average cut-off level for tender design and initial load test can be assumed as _____* m below ground level.

A4. A protocol shall be signed between BHEL site and contractor regarding,

Strata at the founding depth

Installation criteria

Socketing depth

Density of bentonite before concreting

Slump of concrete.

Time interval between end of boring and start of concreting,

* Values shall be indicated separately depending upon subsoil strata of the site.

ANNEXURE-B

List of Equipments

S. No	Description	Capacity No.
1.	Piling Rigs	
2.	Chisel	3 T min 6 T max
3.	High pressure Mud Pumps	10 HP min 25 HP max
4.	Bentonite mixing plants	
5.	Concrete batching plant	
6.	Soil testing equipments	

Note:

1. The no. and capacity of the piling equipment varies for each work.

2. Additional equipments shall be mobilized if required as per the directions of the Engineer to match the work schedule at no extra cost to the Owner.

ANNEXURE-C

Bentonite suspension used for piling work shall satisfy the following requirements

a) Liquid limit of bentonite when tested in accordance with IS: 2720(Part V) shall be more than 300 percent and less than 450 percent.

b) Sand content of the bentonite powder shall not be greater than 7 percent.

c) Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the freshly prepared bentonite suspension shall be between 1.034 and 1.10 gm/ml depending upon the pile dimensions and type of soil in which the pile is to be installed. However, the density of bentonite suspension after mixing with deleterious materials in the pilebore may be upto 1.25 gm/ml.

d) The Marsh viscosity when tested by a Marsh cone shall be between 30 to 60 seconds.

e) The differential free swell shall be more than 540 percent.

f) The pH value of the bentonite suspension shall be between 9 and 11.5.

ANNEXURE-D

PILE DATA

1. Reference No. Location (Co-ordinates) _____area.
2. Sequence of Piling
3. Pile diameter & Type
4. Working level (Platform level)
5. Cut off level (COL)
6. Actual length below COL
7. Pile termination level
8. Top of finished concrete level
9. Date and time of start and completion of boring.
10. Depth of Ground water table in the vicinity.
11. Type of soil at pile tip
12. Method of boring operation
13. Details of drilling mud as used:

    i) Freshly supplied mud
    Liquid limit -

    Sand content -

    Density -

    Marsh viscosity -

    Swelling index -

    pH value -

    ii) Contaminated mud
    Density -

    Sand content -

14. SPT* N values in soil (from the nearest bore hole).
+UCS** value in rock (from the nearest bore hole).

* Standard penetration Test
** Unconfined compression strength

15. Chiselling if any, from..….. m to ….... m

16. Date and time of start and completion of concreting.

17. Method of placing concrete

18. Concrete quantity
Actual

Theoretical

19. Ref. Number of test cubes

20. Grade and slump of concrete

21. Results of test cubes

22. Reinforcement details:

Main Reinforcement	Stirrups: Type
No._____	No._____
Dia. _____	Dia._____
Depth _____	Spacing _____

23. Any other information regarding obstructions, delay and other interruption to the sequence of work.

TABLE -1

FREQUENCY OF SAMPLING AND TESTING

SI. No	Type of material work	Nature of Test/ characteristics	Method of Test & frequency	No. of test	Acceptance Criteria
1.	Pilebore size a) diameter b) length		Physical measurement	each pile	as per specification
2.	Founding level	to establish socketing horizon/ and or founding level & upto depth 5m below founding level.	in separate borehole meant for the purpose a) SPT in soils/ weathered rock b) Core & UCS value of rock	1 borehole for 100-150 piles or group of 150 Sqm	Annexure - B
3.	Bentonite (Mud) properties. a) Basic properties of bentonite before use. b) Contaminated mud from pile bore bottom before concreting	Liquid Limit, Marsh Viscosity, Specific gravity, sand content, swelling index, pH value. Density, sand content	in lab in lab	As per Cl. 5.7 Each Pile	As per Annexure C As per annexure C
4.	Position and Alignment	-	Physical or any Approved method	Each Pile	As per Cl. 4.3
5.	Cleaning of pilebore	-	As per Cl. 5.8	Each Pile	Pilebore be free from bored material debris/sludge
6.	Reinforcement (R/F) Spacing of longitudinal R/F cover laps binding of laterals		Physical inspection and measurement	each cage	As per approved design
7.	Concrete a) Workability b) Cubes	 Slump cone test Compressive Strength test	 Each pile As per spec.	 As per Cl. 5.5 As per Cl. 5.5	 As per specification. As per IS: 456
8.	Materials like aggregate, sand etc.	As per technical specification for concrete and relevant IS codes			
9.	Pile head		Physical	each pile	

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SECTION - D

SUB-SECTION – D22

SITE LEVELLING & GRADING WORKS

SPECIFICATION NO. PE-TS-999-600-C022

Maharatna Company

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
1.00.00	GENERAL	3
2.00.00	SCOPE	3
3.00.00	MATERIALS	4
4.00.00	QUALITY CONTROL	6
5.00.00	EXECUTION	6
6.00.00	RATES AND MEASUREMENTS	15

GENERAL TECHNICAL SPECIFICATION FOR SITE LEVELLING AND GRADING

1.00 GENERAL

This specification covers the works to be carried out for **"Site Levelling and Grading Works including Slope Protection"** etc. for the entire plant and associated areas. The specified formation level(s) shall be achieved either by excavation or by raising with controlled fill with excavated/borrowed earth as the case may be.

2.00 SCOPE

2.01 The scope include all works involved in levelling the site to the lines, grades, cross sections and dimensions as shown on the approved drawings and/or as directed by the engineer including site clearance, setting out, earth work in excavation, stacking, loading, transportation, unloading, dewatering, drainage, filling, watering, compaction, turfing on slopes (if required), lighting, disposal of residual/surplus earth etc. It also includes supplying and providing all labour, materials, supervision, services, equipments, tools and plants, testing and all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work etc.

2.02 All tools and plants, equipments and machineries to be used in this work shall be of standard quality and manufactured by reputed concerns conforming to Indian Standard (IS) codes or equivalent thereof.

2.03 Work to be provided by the Contractor

The works to be provided by the contractor unless specified otherwise shall include but not be limited to the following.

a) Supplying and providing all labour, supervision, services including as required under statutory labour regulations, materials, equipments, tools and plants, approaches, transportation etc. required for the completion of the work.

b) Preparation and submission of detailed scheme of all operations required for executing the work (material handling, placement, services, approaches etc.) to the engineer for approval.

c) Carrying out sampling and testing on fill materials/fills to assess the quality/moisture content/degree of compaction and submission of the test results whenever required by the engineer.

d) Design, construction and maintenance of Magazine of proper capacity for storage of explosives for blasting work and removal of the same after completion of the work etc.

2.04 Work to be provided by others

No work under this specification will be provided for by any agency other than the contractor unless specifically mentioned elsewhere in the contract.

2.05 Codes and Standards

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) codes unless specified otherwise.

IS: 1200 Methods of measurement of building and civil engineering works, Part-1: Earthwork

IS: 2720 Method of test for soils (Relevant parts)

IS: 3764 Excavation work- Code of safety

IS: 4081 Safety code for blasting and related drilling operations

IS: 4701 Code of practice for earthwork on canals

IS: 6922 Criteria for safety and design of structures subject to underground Blasts

In case of conflict between this specification and those (IS codes) referred to herein, the former shall prevail. In case any particular aspect of work is not covered specifically by the specification or/and by the IS codes, any other standard practice as may be specified by the engineer shall be followed.

2.06 Conformity with Designs

The contractor shall carry out the work as per the approved drawings, specification and as directed by the engineer.

3.00 MATERIALS

All materials required for the work shall be of best variety and approved by the engineer.

3.01 Materials for Excavation

For the purpose of identifying the various strata met during the course of excavation, the following classification is to be followed.

a) Soil

It includes all type of soil including laterite, moorum etc. with/without any percentage of kankar which can be excavated by normal means such as shovel, pick axe, crow bar, spade etc. and those which do not fall under **clause** 3.01 (b) and (c) etc.

b) Soft Rock

It includes the rocks (including weathered rock) which are removable by splitting with the help of crow bar, pick axe, wedges, pavement breakers, pneumatic tools, hammers or such implements etc. and not requiring blasting (for excavation) in the opinion of the engineer.

c) Hard Rock

It includes the rocks, which require blasting for excavation in the opinion of the engineer. Where blasting is prohibited for any reasons, the excavation shall be carried out by chiseling or any other method as approved by the engineer. The mere fact that the contractor resorts to blasting shall not classify the soft rock under hard rock.

However, the engineer's decision on the type of strata encountered during excavation shall be the final and binding on the contractor.

3.02 Materials for Filling

Any coarse grained or fine grained low plastic soil free from vegetation, roots, shingle, salts, organic matters, sod and any other harmful chemicals shall be used for filling. The contractor shall test the fill material to establish its suitability and submit the results to the engineer for approval. Fill material shall be got approved by the engineer. The following type of materials shall not be used for filling.

a) Materials from swamps, marshes and bogs
b) Expansive clays
c)Peat, logs, sod and perishable materials
d)Materials susceptible to combustion
e) Any material or industrial and domestic produce which will adversely affect other materials of work
f) Materials from prohibited areas

The earth available by cutting the high grounds within the project site and the materials (if) available from the road excavation or any other excavation under the same contract shall be used for filling depending upon its suitability as fill material. Filling with excavated rock (in the project site) shall be done only with the written permission of the engineer in the following manner. The boulders shall be broken into pieces not exceeding 150mm size in any direction and mixed with fine materials consisting of decomposed rock, moorum or any

approved earth to fill the voids as for as possible and the mixture shall then be used for filling. In case the earth required for filling is over and above the earth available from the compulsory excavations within the project area, then borrow areas for obtaining suitable fill material shall be arranged by the contractor himself from outside the plant boundary limits and all expenses including royalties, taxes, duties etc. shall be borne by him. He shall obtain and submit the necessary clearances/permissions from the concerned authorities to the engineer for the borrow areas/materials acquired.

4.00 QUALITY CONTROL

All works shall conform to the lines, levels, grades, cross sections and dimensions shown on the approved drawings and/or as directed by the engineer. The contractor shall establish and maintain quality control for the various aspects of the work, method of construction, materials and equipments used etc. The quality control operation shall include but not be limited to the following.

Sl. No.	Activity	Check
1	Lines, levels & grades	a) By periodic surveys b) By establishing markers, boards etc
2	Filling	(a) On quality of fill material (b) On moisture content of fill material (c) On degree of compaction achieved

5.00 EXECUTION

The contractor shall prepare and submit the detailed drawings/schemes for excavation and filling works as proposed to be executed by him showing the dimensions as per the construction drawings and specification adding his proposal of approaches, dewatering (if any), drainage and compaction etc. within 15 days of award of the contract to the engineer for approval.

5.01 Site Clearance

Before the commencement of earthwork, the entire area of cutting and filling shall be cleared of all trees, stumps, bushes, grasses, vegetation etc. with their roots, fences, logs, rubbish, water, slush etc. It is not necessary to remove all the soil containing fine hair like roots but only the rather heavy mats are to be removed. Cutting of trees shall include trees having girth of any size and removing roots upto a depth of 600mm below the existing ground level or 300mm below the formation level whichever is deeper. After the removal of roots of trees, the pot holes formed shall be filled with good earth in 250mm layers (loose thickness) and compacted unless otherwise directed by the engineer. The trees shall be cut in to suitable pieces as instructed by the engineer. Before earthwork is started, all the spoils, unserviceable materials and rubbish shall be burnt or removed and disposed off to the approved disposal area(s) as specified by the engineer. Useful materials, saleable timbers, fire

woods etc. shall be the property of owner and shall be stacked properly at the worksite in a manner as directed by the engineer.

5.02 Setting Out

On receiving the approval from the engineer with modifications and corrections if any, the contractor shall set out the work from the control points furnished by the engineer and fix permanent points and markers for the ease of periodic checking as the work proceeds. These permanent points and markers shall be fixed at the interval as prescribed by the engineer and shall be got checked and certified by the engineer after whom the contractor shall proceed with the work. It should be noted that this checking by the engineer prior to the start of the work will in no way relieve the contractor of his responsibility of carrying out the work to true lines, levels and grades as per the drawings and specification. If any errors are noticed in the contractor's work at any stage, the contractor at his own risk and cost shall rectify the same. The contractor shall take spot levels of the area (with respect to the bench mark/ available source as provided by the engineer) to be excavated or to be filled at an interval of not more than 10m or as directed by the engineer before starting any earth work and shall be submitted to the engineer for prior approval.

5.03 Excavation

Levelling by excavation shall be carried out where the existing ground levels are higher than the specified formation level. Excavation shall include removal of all materials whatever nature as may be and whether wet or dry shall be carried out exactly in accordance with the line, levels, grades and curves shown on the approved drawings and/or as directed by the engineer. All excavations shall be done to the minimum dimensions as required. The contractor shall obtain prior approval of the engineer for the method he proposes to adopt for excavation in different types of strata including dimensions, side slopes and dewatering if any, stacking or disposal etc. This approval however shall not in any way make the engineer responsible for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. The work shall be carried out in a workmanlike manner without endangering the safety of nearby structures/services or works and without causing hindrance to any other activities in the area. **Prior to starting the excavation, the ground level at the location shall be checked jointly with the engineer.**
The rough excavation may be carried up to a maximum depth of 150mm above the final formation level. The balance shall be excavated with special care and the final surface shall be compacted by rolling with 6 passes of 8 to 10 tonne roller. If directed by the engineer, soft and undesirable spots shall be removed even below the final level. The extra excavation shall be filled up with good earth in 250mm layers (loose thickness) and compacted unless otherwise directed by the engineer. The contractor shall be paid for the extra excavation and filling at the appropriate items of work.

If the excavation is done to a depth greater than that shown on the drawing or as directed by the engineer due to the contractor's fault, the excess depth shall be

filled up to the required level with good earth in 250mm layers (loose thickness) and compacted unless otherwise directed by the engineer at the own risk and cost of the contractor.

Suitable slope in cutting as per the requirements and as directed by the engineer shall be adopted to withhold the face of earth. The contractor shall be held responsible for any damage to any part of the work caused by the collapse of the side of excavations.

5.03.01 Excavation in Hard Rock

Excavation in hard rock shall normally be done with blasting. In case where blasting is prohibited for any reasons, the excavation shall be carried out by chiselling or any other approved method as directed by the engineer. Personnel deployed for rock excavation shall be protected from all hazards such as loose rock/boulder rolling down and from general slips of excavated surfaces.

5.03.02 Blasting

a) General

Storage, handing and use of explosives shall be governed by the current explosive rules/regulations laid down by the Central and the State Governments. The contractor shall ensure that these rules/regulations are strictly adhere to. The following instructions are also to be strictly followed and the instructions wherever found in variance with the above said rules/regulations, the former (instructions) shall be superseded with the later (above said rules/regulations).

No child under the age of 16 and no person who is in a state of intoxication shall be allowed to enter the premises where explosives are stored nor they shall be allowed to handle the explosives. The contractor shall obtain licence from the District Authorities for undertaking the blasting work as well as for obtaining and storing the explosives as per Explosives Rules, 1940 corrected upto date. The contractor shall purchase the explosives, fuses, detonators etc only from a licensed dealer and shall be responsible for the safe custody and proper accounting of the explosive materials. The engineer or his authorized representative shall have the access to check the contractor's store of explosives and his accounts at any time. It is the full responsibility of the contractor to

transport the explosives as and when required for the work in a safe manner to the work spot.

Further, the engineer may issue modifications, alterations and new instructions to the contractor from time to time. The contractor shall comply with the same without these being made a cause for any extra claim.

b) Materials

All materials such as explosives, detonators, fuses, tamping materials etc proposed to be used in the blasting operation shall have the prior approval of the engineer. Only explosives of approved make and strength are to be used. The fuses known as instantaneous fuse must not be used. The issue of fuse with only one protective coat is prohibited. The fuse shall be sufficiently water resistant as to be unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and shall be not less than 4 seconds per inch of length with 10% tolerance on either side. Before use, the fuse shall be inspected. Moist, damaged or broken ones shall be discarded. When the fuses are in stock for long, the rate of burning of fuses shall be tested before use. The detonators shall be capable of giving an effective blasting of the explosives. Moist and damaged detonators shall be discarded.

c) Storage of Explosives

The current Explosive Rules shall govern the storage of explosives. Explosives shall be stored in a clean, dry and well-ventilated magazine to be specially built for the purpose. Under no circumstances should a magazine be erected within 400m of the actual work site or any source of fire. The space surrounding the magazine shall be fenced and the ground inside shall be kept clear and free from trees, bushes etc. The admission to this fenced space shall be through a single gate only and no person shall be allowed without the permission of the officerin-charge. The clear space between the fence and the magazine shall not be less than 90m. The magazine shall be well drained. Two lightning conductors, one at each end shall be provided to the magazine. The lightning conductors shall be tested once in every year.

Explosives, fuses and detonators shall each be separately stored. Cases of explosives must be kept clear of the walls and floors for free circulation of air on all sides. Special care shall be taken to keep the floor free from any grains of explosives. Cases containing explosives shall not be opened inside the magazine and the explosives in open cases shall not be received into a magazine. Explosives which appear to be in a damaged or dangerous condition are not to be kept in any magazine but must be removed without delay to a safe distance and be destroyed.

Artificial light, matches, inflammable materials, oily cotton, rag waste and articles liable to spontaneous ignition shall not be allowed inside the magazine.

Illumination shall be obtained from an electric storage battery lantern. No smoking shall be allowed within 100m distance from any magazine.
Magazine shoes without nails shall be used while entering the magazine. The persons entering the magazine must put on the magazine shoes which shall be provided at the magazine for this purpose and should be careful

* not to put their feet on the clean floor unless the magazine shoes on.

* not to touch the magazine shoes on ground outside the clean floor.

* not to allow any dirt or grit to fall on the clean floor.

Persons with bare feet shall dip their feet in water before entering the magazine and then step directly from the tub to the clean floor. No person having article of steel or iron with/on him shall be allowed to enter the magazine. Workmen shall be examined before entering the magazine to check none of the prohibited articles are with them. A brush broom shall be kept in the lobby of the magazine for cleaning the magazine. Cleaning shall be done immediately after each occasion whenever the magazine is opened for receipt, delivery or inspection of the explosives.

The mallets, levers, wedges etc for opening the barrels or cases shall be of wood. The cases of explosives are to be carried by hand and shall not be rolled or dragged inside the magazine. Explosives which have been issued and returned to the magazine are to be issued first; otherwise those which have been stored long in the store are to be issued first. Neither the magazine shall be opened nor any person shall be allowed in the vicinity of the magazine during any dust storm or thunderstorm. All magazines shall be officially inspected at definite intervals and a record of such inspections shall be kept.

d) Carriage of Explosives

Detonators and explosives shall be transported separately to the blast site. Explosives shall be kept dry and away from direct rays of the sun, artificial lights, steam pipes or heated metal and other sources of heat. Before explosives are removed, each case or package shall be carefully examined to ascertain that it is properly closed and shows no sign of leakage.

No person except the driver shall be allowed to travel on the vehicle conveying explosives. No explosive shall be transported in a carriage or vessel unless all iron or steel therein the carriage or vessel which are likely to contact the package containing explosives are effectually covered with lead, leather, wood, cloth or any other suitable material. No light shall be carried on the vehicle carrying explosives and no operation connected with the loading, unloading and handling of explosives shall be conducted after sunset.

e) Use of Explosives

The contractor shall appoint an agent who shall personally superintend the firing and all operations connected therewith. The contractor shall satisfy himself that the person so appointed is fully acquainted with his responsibilities. Holes for charging the explosives shall be drilled with pneumatic drills and the drilling pattern shall be so planned that the rock pieces after blasting will be suitable for handling. The hole diameter shall be of such a size that the cartridges can easily pass down through them and any undue force is not required during charging. Charging operation shall be carried out by or under the personal supervision of the shot firer. Wrappings shall never be removed from the explosive cartridges. Only one cartridge at a time shall be inserted in a hole and wooden rods shall only be used for loading and stemming the shot

holes. Only such quantities of explosives as are required for a particular work shall be brought to the work site. Should any surplus remain when all the holes have been charged shall be carefully removed to a point at least 300m away from the firing point.

The authorized shot firer himself shall make all the connections. The shot firing cable shall not be dragged along the ground to avoid any damage to the insulation. The shot firing cable shall be tested each time for its continuity and possible short circuiting. The shot firer shall always carry the exploder handle with him until he is ready to fire shots. The number of shots fired at a time shall not exceed the permissible limits. Before any blasting is carried out it shall be ensured that all workmen, vehicles and equipment on the site are cleared from an area of minimum 300m radius from the firing point or as required by the statutory regulations at least 10 minutes before the time of firing by sounding a warning siren and the area shall be encircled by red flags.

The explosives shall be fired by means of an electric detonator placed inside the cartridge. For simultaneous firing of a number of charges, the electric detonators shall be connected with the exploder through the shot firing cable in a simple series circuit. Due precautions shall be taken to keep the firing circuit insulated from the ground, bare wires, rails, pipes or any other path of stray current etc. and keep the lead wires short circuited until it is ready to fire. Any kink in the detonator leading wire shall be avoided. For simultaneous firing of a large number of shot holes, use of cordtex may be done. An electric detonator attached to its side with adhesive tape shall initiate cordtex connecting wire or string. Blasting shall only be carried out at certain specified times to be agreed jointly by the contractor and the engineer.

At least five minutes after the blast has been fired in case of electric firing or as stipulated in the regulations, the authorized shot firer shall return to the blast area and inspect carefully the work and satisfy himself that all the charged holes have exploded. Cases of misfired unexploded charges shall be exploded by drilling a parallel fresh hole at a distance of not less than 600mm from the misfired hole and by exploding a new charge. The authorized shot firer shall be

present during the removal of debris as it may contain unexploded explosives near the misfired hole. The workmen shall not return to the site of firing until at least half an hour after firing.

Where blasting is to be carried out in proximity of other structures, controlled blasting by drilling shallow shot holes and proper muffling arrangements with steel plates loaded with sand bags etc. shall be used on top of the blast holes to prevent the rock fragments from causing any damage to the adjacent structures and other properties. Adequate safety precautions as per building byelaws, safety codes, statutory regulations etc. shall be taken during blasting operations.

5.03.04 Restrictions on Blasting

a) Blasting which may disturb or endanger the stability, safety or quality of the adjacent structures/foundations shall not be permitted.
b) Blasting within 200m of a permanent structure or construction work in progress shall not be permitted.
c) Progressive blasting shall be limited to two third of the total remaining depth of excavation.
d) No large scale blasting operations will be resorted to when the excavation reaches the last one meter and only small charge preferably black powder may be allowed so as not to shatter the parent rock.
e) The last blast shall not be more than 0.50 m in depth.
f) In rocky formations, at locations where specifically indicated or ordered in writing by the engineer, the use of explosives shall be discontinued and excavation shall be completed by chiseling or any other suitable method as approved by the engineer.

5.04 Sorting of Excavated Materials

The excavated material shall be carefully sorted for use in filling the areas in the project site by removing roots, grasses, organic matters and other objectionable materials and be sorted out into different types of materials for use and as directed by the engineer. The excavated material which is not considered fit for filling purpose shall be immediately removed and disposed at such a place and in such a manner as will be directed by the engineer. The material found unusable should be got approved by the engineer before actually disposing it off. The useful materials that cannot be used directly shall be heaped in separate area as stock piles. Stockpiles shall be of regular size as for as possible for ease of measurement. The materials heaped shall be utilized as and when required and as directed by the engineer. The cost of complete item of earthwork includes the cost of rehandling of the materials and temporarily heaped and reused.

5.05 Disposal of Surplus/ Waste Materials

Surplus and other waste materials shall be removed and disposed of from the construction site to the area demarcated by the engineer. No material shall be wasted unless approved by the engineer.

5.06 Earth Work in Filling

Levelling by raising with controlled fill of approved excavated/borrowed earth shall be carried out where the existing ground levels are lower than the specified formation level. After clearing site as per clause 5.01, the original ground shall be compacted by rolling subject to a minimum 6 passes of 8 to 10 tons' roller. The approved earth/fill material shall then be spread in horizontal layers' not exceeding 300mm in compacted thickness. Each layer shall be watered and thoroughly compacted with proper moisture content and such equipments as may be required to obtain a minimum of 95% of its maximum dry density as

determined by standard Proctor's test as per IS: 2720 part-VII or 85% of relative density as per IS:2720 part-XIV as specified. Moisture content of the fill material shall be controlled near optimum moisture content during compaction.

The fill material shall be tested for its optimum moisture content and maximum dry density as per IS: 2720, part-VII. Moisture content shall be checked at the source of supply in accordance with IS:2720 part- II and if found less than that required for proper compaction, the same shall be made good either at the source or after spreading the soil in loose thickness for compaction. In the latter case, water shall be sprinkled directly from the hose line or from the truck-mounted water tank etc. making due allowance for evaporation losses and the fill material be thoroughly mixed by means of harrows, rotary mixers or by any other suitable approved method until the layer is uniformly wet. **Flooding shall not be permitted for watering purpose under any circumstances.** If the material delivered is too wet, it shall then be dried by aeration and exposure to the sun till the moisture content is suitable for compaction. Should circumstances arise owing to wet weather the moisture content cannot be reduced to the required amount by the above procedure, the work on compaction shall be suspended. Clods or hard lumps of earth shall be broken to have a maximum size of 150mm when being placed in the layers before compaction. For each of the above tests on the fill material, one sample for every 10,000cu.m shall be tested. Additional samples shall be tested whenever there is a change of source or type of material.

Before start of filling, the contractor shall submit the engineer his proposal for the methodology to be adopted for compaction. The compaction equipments as approved by the engineer shall only be employed to compact the different type materials encountered during construction. If directed by the engineer, the contractor shall demonstrate the efficacy of the plant he intends to use by carrying out compaction trials. Moisture content of the fill material shall be controlled near optimum moisture content during compaction.

The compacted layer shall be tested for its dry density as per IS:2720**,** part-XXVIII or XXIX as directed by the engineer. Samples shall be taken at the rate of one sample for every 10,000sq.m area of each compacted layer. In addition random checks shall be carried out in compacted layers by means of Proctor needle penetration test. Contractor shall submit all the test results to the engineer immediately after completion of the tests. A sample shall be deemed to have passed the test when the dry density of the compacted fill is equal to or more than 95% of its maximum dry density. When field density measurements reveal any soft areas in the fills, further compaction shall be carried out as directed by the engineer. If in spite of that, the specified compaction is not achieved, the material in the soft areas shall be replaced with approved material compacted to the density requirements and satisfaction of the engineer.

Subsequent layers shall be placed only after the finished layer has been tested and accepted by the engineer.

Where the filling is to be done across low swampy ground that will not support the weight of trucks or other hauling equipments, the lower part of the fill shall be constructed by dumping successive loads in a uniformly distributed

layer of a thickness not greater than that necessary to support the hauling equipment while placing subsequent layers.

5.07 Dewatering and Drainage

It shall be ensured that the area to be excavated/filled shall be free from water. The contractor shall remove the water (if any) by pumping or by any other means as approved by the engineer. At all times, the surface of cutting/filling during execution shall be maintained at such a cross fall as will shed water and prevent ponding. All existing drains/channels (if any) in the work area shall be suitably diverted by the contractor before taking up any excavation or filling. These diversions shall be such that it shall ensure effective disposal of water without any accumulation or flooding within the project site and in adjoining areas.

5.08 Finishing Operations

Finishing operation shall include the work of shaping and dressing the excavated/filled ground to the required grades, levels, lines, side slopes, cross-sections
and dimensions as shown on the approved drawings or as directed by the engineer.

5.09 Turfing

Turfing shall be provided at the slopes and other locations as shown on the drawings or as directed by the engineer. The turf shall be of approved quality of grass. The sod shall consist of dense, well rooted growth of permanent and desirable grasses indigenous to the locality where it is to be used and shall be practically free from weeds or other undesirable matter. The grass on the sod shall have a length of approximately 50mm and the sod shall be free of any

debris. Thickness of the sod shall be as uniform as possible with 50 to 80mm of soil covering the grass roots depending on the nature of the sod so that all the dense root system of the grasses is retained in the sod strip. The sods shall be cut in rectangular strips of uniform width not less than about 300mm x 250mm size but not so large so that it is convenient to handle and transport without damage.

The area to be sodded shall be previously constructed to the required slope and cross section. Prior to placing the sods, the slopes shall be **roughned** and wetted in order to have a satisfactory bond. The strips of sod shall be laid in close contact with each other and be tamped firmly in place so as to fill and close the joints between them. The turfing so laid shall be well watered and protected until final acceptance.

5.10 Approaches

The contractor shall provide proper approaches for workmen and inspection.

5.11 Lighting

Full scale lighting is to be provided if night work is permitted or directed by the engineer. If no night work is in progress, red warning lights should be provided at the edges of excavations and fills.

6.00 RATES AND MEASUREMENTS

6.01 Rates

a) The item of work in the schedule of quantities describe the work very briefly. The various items of the schedule of quantities shall be read in conjunction with the corresponding sections in the technical specification including amendments and additions if any. For each item in the schedule of quantities, the bidder's rate shall include all the activities covered in the description of the items as well as for all necessary operations in detail as described in the technical specification.

b) No claims shall be entertained if the details shown on the released for construction drawings differ in any way from those shown on the tender drawings.

c) The unit rate quoted shall include minor details which are obviously and fairly intended and which may not have been included in these documents but are essential for the satisfactory completion of the work.

d) The bidder's quoted rate shall be inclusive of supplying and providing all labour, men, materials, equipments, tools and plants, supervision, services, approaches, schemes etc.

6.02 Measurements

Method of measurements are specified in the proceeding sections. Where not so specified, the latest version of IS:1200, Part-1 shall be applicable.

a) The length, breadth and depth shall be measured correct to the nearest centimeter if measurements are taken by tape. Rounding of numerical shall be as per relevant IS Codes. If the measurements are taken with staff and level, the levels shall be recorded correct to 5mm. The area and volume shall be worked out in square meter and cubic meter correct to the nearest of two decimal places.

b) For earth work in excavation, the ground levels shall be taken before and after completion of the work in the actually excavated area. The quantity of earth work in cutting shall be computed from these levels in cubic meter.

c) Where soft rock and hard rock are mixed, the measurement shall be done as follows. The two types of rock shall be stacked separately and measured in

stacks. The net quantity of each type of rock shall be so arrived by applying a deduction of 50% for looseness/voids in the stacks. If the sum of net quantity of the two types of rock so arrived exceeds the total quantity of excavation then the quantity of each type of rock shall be worked out from the total quantity (from excavation) in the ratio of net quantities in stack measurements of the two types of rock. If stacking is not feasible, the method as suggested by the engineer shall be followed.

d) Where soil, soft rock and hard rock are mixed, the measurement shall be done as follows. The soft and hard rock shall be removed from the excavated material and stacked separately and measured in stacks. The net quantity of each type of rock shall be so arrived by applying a deduction of 50% for looseness/voids in stacks. The difference between the entire excavation and the sum of the quantities of soft and hard rocks so arrived shall be taken as soil.

e) For earth work in filling, the actual measurements of fill shall be calculated by taking levels of the original ground before start of the work but after site clearance and after compaction of fills. The quantity of earth work in filling shall be computed from these levels in cubic meter.

f) For turfing, the measurement shall be made on the finished work in square meter.

VOLUME – II B

SECTION – D

SUB SECTION – D23

ANTI-TERMITE TREATMENT

SPECIFICATION NO. PE-TS-999-600-C023

Maharatna Company

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

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TECHNICAL SPECIFICATION FOR ANTI-TERMITE TREATMENT

1.00.00 SCOPE

The scope of work is to set up a chemical barrier against attack by subterranean termites while the building is under construction.

2.00.00 EXECUTION

2.01.00 General

All work shall in general be executed as specified in IS: 6313 Part II-1981 and as per approved specification of the agency having special know-how for the job.

All necessary work to ensure uniform distribution and proper penetration of treatment of treating solution shall be done according to the instruction of the Engineer.

Soil treatment shall not be done when it is raining or when the soil is wet with rain or subsoil water. Once formed, the treated soil barrier shall not be disturbed.

2.02.00 Chemicals and Rate of Application

Any of the following chemicals (conforming to relevant Indian Standards) in water emulsion shall be applied by pressure pumps, uniformly over the area treated.

Chemicals		Concentration by Weight, Percentage
Chlorpyrifos Emulsifiable (IS 8944 - 1978)	:	1.0
Heptachlor Emulsifiable Concentrate (IS: 6439 - 1978)	:	0.5
Chlordane Emulsifiable Concentrate (IS: 2682 - 1984)	:	1.0

2.02.01 Treatment of Column Pits, Wall Trenches and Basement Excavations

Foundations, basements etc. may either be fully enveloped by the chemical barrier or the treatment may start 500 mm below ground level. The bottom surface and sides of excavation (upto a height of about 300 mm) for column

pits, walls trenches and basements shall be treated with chemicals at the rate of 5 litres / M^2 of surface area. Backfills around columns, walls etc. shall be treated at the rate of 7.5 litres / M^2 of the vertical surface.

Chemical treatment shall be done in stages following the compaction of earth in layers. The treatment shall be carried out after the ramming operation is done by rodding the earth at 150 mm centres close to the wall surface and spraying the chemicals in the specified dose.

2.02.02 Treatment of Top Surface of Plinth Filling

Holes 50 mm to 75 mm deep at 150 mm centres both ways shall be made with crowbars on the surface of compacted plinth fill. Chemical emulsion at the rate of 5 litres / M^2 of surface shall be applied prior to laying soling or sub-grade. Special care shall be taken to maintain continuity of the chemical barrier at the junction of vertical and horizontal surfaces.

2.02.03 Treatment of Soil Surrounding Pipes, Wastes and Conduits

Special care shall be taken at the points where pipes and conduits enter the building and the soil shall be treated for a distance of 150 mm and a depth of 75 mm at the point where they enter the building.

2.02.04 Treatment of Expansion Joints

These shall receive special attention and shall be treated in a manner approved by the Engineer.

2.02.05 Treatment at Junction of the Wall and the Floor

Special care shall be taken to establish continuity of the vertical chemical barrier on inner wall surfaces from ground level up to the level of the filled earth surface.
A small channel 30 x 30 mm shall be made at all the junctions of wall and columns with the floor. Rod holes made in the channel up to the ground level 150 mm apart and the chemical emulsion poured along the channel at the rate of 7.5 litres per square meter of the vertical wall or column surface. The soil should be tamped back into place after this operation.

3.00.00 ACCEPTANCE CRITERIA

The Contractor shall give a 10-year service guarantee in writing supplemented by a separate and unilateral guarantee from the specialised agency for the job to keep the building free of termites for the specified period.

4.00.00 RATES

Rates shall be of complete work per unit area as stated in the Schedule.

5.00.00 METHOD OF MEASUREMENT

Complete work of anti-termite treatment shall be measured for plinth area treated.

This includes treatment, to foundations, walls, trenches, basements, plinth, burried pipes, conduits etc. The extended portions of foundation and like beyond plinth limit shall be the part of complete work.

6.00.00 I.S. CODE

Relevant code applicable for this Specification.

IS: 6313 (Part-II) 1981 : Code of Practice of Anti-Termite Measures in Buildings
Pre-constructional chemical treatment measures.

2x700 MWe NPCIL GHAVP 1&2 NUCLEAR POWER PROJECT

(TG – ISLAND PACKAGE)

TECHNICAL REQUIREMENT

FOR CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

VOLUME: II B

(SECTION-C)

DOCUMENT NO. PE-TS-486-600-C001

REVISION 00

BHARAT HEAVY ELECTRICALS LIMITED
PROJECT ENGINEERING MANAGEMENT
PPEI BUILDING, POWER SECTOR,
PLOT NO. 25, SECTOR-16A,
NOIDA -201301

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PART-I : GENERAL CIVIL REQUIREMENT

PART-II : SPECIFIC TECHNICAL REQUIREMENTS

PART – I

GENERAL CIVIL REQUIREMENT

1.0 General

Two Volumes – Section C & Section D of this specification cover site survey, soil investigation, site development works, design and construction of Civil, Structural and Architectural works. The scope of works covers complete Civil, Structural and Architectural Works including supply of all materials, labour, tools and plants as required for successful execution of this package.
Section-C contains two Part i.e. Part-I and Part-II. Part-I of Section-C describes general requirements. Part-II describes specific technical requirement.

Technical specification Section C and Section D shall be read in conjunction with Bill of Quantities. If there is any ambiguity and/or contradiction between Part-I and Part-II of Section-C, the provisions/requirement laid in Part-II shall prevail. If there is any ambiguity and/or contradiction between Section C and Section D, the provisions/ requirement laid in Section C shall prevail. If there is any ambiguity and/or contradiction between Section C and BOQ, the provisions/ requirement laid in BOQ shall prevail.

(Contractor shall read the parts of the specification relevant to the contract and shall ignore other parts of the specification. Relevant clauses of this section as applicable for respective package to be followed)

All the quality standards, tolerances, welding standards and other technical requirements shall be strictly adhered to. The bidder shall fully apprise himself of the prevailing conditions at the proposed site, climatic conditions including monsoon pattern, soil conditions, local conditions and site specific parameters and shall include for all such conditions and contingent measures in the bid, including those which may not have been specifically brought out in the specifications. In case of any conflict between stipulations in various portions of the specifications, most stringent stipulation would be applicable for implementation by the bidder without any extra cost to the employer.

2.0 LAYOUT

Before starting the work, the contractor shall carry out the setting out of foundation and structures and provide levels with reference to general existing grid and bench mark. If the contractor uses the grid, bench mark and reference pillar made by other contractors, he shall coordinate with the contractor and shall satisfy himself of the accuracy of the reference marks. If he is required to set out the foundation afresh, he shall do so independently with reference to the existing grid and bench mark which has been followed by other agency at the instruction of the Engineer. In case any discrepancy is found, it shall be immediately brought to the notice of the Engineer for any rectification/modification necessary. No complaint shall be entertained at a later stage. The contractor shall accurately set out the position for holding down bolts and inserts.

If required, in the opinion of the Engineer, he shall construct and maintain pillars for grid, references and bench marks and maintain them till the completion of the construction. He shall also help the Engineer with instruments, materials and labours for checking the detailed layouts and levels. The contractor shall be solely responsible for the correctness of the layout and levels, and Engineer's approval shall not be deemed to imply any warranty in carrying out the works correctly. The Tenderer's shall take into account the cost of these in quoting their price.

3.0 WORKMANSHIP

Workmanship shall be of the best possible quality and all work shall be carried out by skilled workmen except for those which normally require unskilled persons. Welding shall be done by experienced and certified welders in proper sequence using necessary jigs and fixtures. Fabrication shall be done in shops having proper equipment for accurate edge and shaping and dimensioning of anchor bolt assembly, inserts and other misc. items. in addition to the requirement specified above, if the bye laws of the local govt., Municipal or the other authorities require the employment of licensed or registered workmen for various trades, the Contractor shall arrange to have the work done by such registered or licensed personnel. In case of manufactured materials, the Contractor shall have, with no additional cost to the Owner, the services of the supervisors of the manufacturers to ensure that the work is being done according to the manufacturer's specifications.

4.0 TEMPORARY WORK

All scaffoldings, staging, temporary bracing and other necessary temporary work required for proper execution of the contract shall be provided by the contractor at its own cost and inclusive of all materials, labour, supervision and other facilities.

The layout and details of such Temporary work shall have the prior approval of the Engineer, but the Contractor shall be responsible for proper strength and safety of the same. All Temporary work shall be so constructed as not to interfere with any permanent work or with the work by the other agencies. If it is necessary to remove any of the temporary work at any time to facilitate execution of the work or with the work of other agencies, such removal and re-erection, if required, shall be carried out by the contractor at the direction of the Engineer without any delay and any extra cost on this account shall be borne by the contractor.

5.0 INTERFACE WITH STRUCTURES UNDER OTHER'S SCOPE

Modification in layout of foundation/structure during engineering stage may be necessary to avoid fouling with those under other's scope. Necessary changes on this account will be made without any extra cost to Owner.

6.0 SEQUENCE OF WORK AND PROGRESS REPORT

The sequence in which the works are to be carried out shall be as approved by the Engineer in accordance with the construction method accepted by the Engineer and to be followed by the Contractor. A programme of work is to be submitted for the Engineer's Review and approval and this has to be periodically updated and modified as per actual progress to enable timely completion.

The Contractor shall regularly submit to the Engineer progress reports for the periods of working as specified by the Engineer showing up to date progress on all important items of work.

7.0 MISCELLANEOUS

The Contractor shall regularly submit and obtain BHEL/NPCIL approval, the following to the Engineer all important items of work.

Preparation of Bar bending schedule and Bill of materials

Design , fabrication and erection of formwork and supporting system required for concreting of the various elements of the structure.

Providing facilities throughout the contract period for sampling and testing of various construction materials as specified and as directed by Purchaser.

Preparation of quality assurance plan, quality assurance manual, testing methodologies Inspection and testing plan, and acceptance criteria for material qualification.

Preparation of construction methodology, safety manual, job hazard analysis, work procedures, etc.

Submission & obtaining the purchaser approval on Construction Completion Certificate & system transfer docket containing necessary documents like Test Certificates, Pour Cards, As Built Drawings & Inspection reports etc.

PART-II

SPECIFIC TECHNICAL REQUIREMENTS

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

GHAVP-1&2/40000/PROCUREMENT SPECIFICATION/MS-1

PROCUREMENT SPECIFICATION
FOR
TURBINE ISLAND PACKAGE
(ENGINEERING, PROCURMENT AND CONSTRUCTION)

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(ENGINEERING, PROCURMENT AND CONSTRUCTION)

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PROCUREMENT SPECIFICATION

FOR

TURBINE ISLAND PACKAGE (TIP)

(ENGINEERING, PROCUREMENT, CONSTRUCTION,

COMMISSIONING & TRIAL OPERATION)

FOR

700 MWe PRESSURISED HEAVY WATER REACTOR TYPE

NUCLEAR POWER PLANT

(GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA-1&2)

PROCUREMENT SPECIFICATION NUMBER: GHAVP-1&2/40000/ PROCUREMENT SPECIFICATION-MS-1

REVISION No. – R0, AUGUST-2018

PROCUREMENT SPECIFICATION

FOR

TURBINE ISLAND PACKAGE (TIP)

(ENGINEERING, PROCUREMENT, CONSTRUCTION, COMMISSIONING

AND TRIAL OPERATION)

FOR

700 MWe PRESSURISED HEAVY WATER REACTOR TYPE
]
NUCLEAR POWER PLANT

(GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA UNIT-1&2)

This specification consists of five (5) sections namely sections A, B, C, D & E. The sections are arranged in different volumes. These five sections contain-

Sections - A : Invitation to tender and tendering conditions
Sections – B : General & special condition of contract
Section - C : Technical requirements
Section - D : Format for submission of part-1 (technical) of the tender
Section - E : Format for submission of part-2 (commercial) of the tender

These sections are arranged in following volumes

Volume - I	:	This volume contain Section A&B.
Volume – II		This volume contains Section C in two parts, C-1 & C-2.
		Part-1 – C-1: General technical requirements
		Part-2- C-2: Specific technical requirements
Volume-III		This volume contain Section D&E.

PROCUREMENT SPECIFICATION NUMBER: GHAVP-1&2/40000/PROCUREMENT SPECIFICATION/MS-1,
PROCUREMENT SPECIFICATION
FOR TURBINE ISLAND

VOLUME-II- Section-C, PART-2

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REVISION No. – R0, AUGUST-2018

VOLUME-II
Section-C (TECHNICAL REQUIREMENTS)
PART-1

C-1: GENERAL TECHNICAL REQUIREMENTS

PROCUREMENT SPECIFICATION NUMBER: GHAVP-1&2/40000/PROCUREMENT SPECIFICATION/MS-1,
PROCUREMENT SPECIFICATION
FOR TURBINE ISLAND
VOLUME-II- Section-C, PART-1

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1.0 PROJECT INFORMATION

1.1	OWNER / PURCHASER	:	NUCLEAR POWER CORPORATION OF INDIA LTD. (NPCIL)
1.2	ENGINEER	:	EXECUTIVE DIRECTOR (PROCUREMENT)
1.3	Project Title	:	2x700 MWe PHWR – GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA - UNITS NO. 1 & 2
1.5	Location	:	GORAKHPUR, VIA: FATEHABAD HARIYANA,
1.6	Elevation (RL)	:	Varies from RL+ 212m to RL+218m
1.7	Nearest Railway Stations	:	UKLANA MANDI (Northern Railways)
1.8	Name of Railway Stations	:	UKLANA MANDI (Northern Railway)
1.9	Ambient Air Temperatures	:	
	a) Maximum dry bulb temperature	:	+48.4 deg C,
	b) Minimum dry bulb temperature	:	-0.1 deg C,
	c) Design temperature for electrical equipment / devices	:	+50 deg C
1.10	Relative Humidity		
	a) Maximum during monsoon	:	100%
	b) Minimum (design)	:	5%
1.11	Air Quality	:	Air quality is clean and free from chemical pollutants.
1.12	Rainfall	:	
	a) Annual Average	:	512 mm

	b)	Highest annual rainfall	:	787 mm in 1997
	c)	Lowest annual rainfall	:	171.1mm in 2000
	d)	Period	:	Year 1969-2007
1.13	Tropicalisation		:	_____
1.14	a)	Wind Pressures	:	

Height above mean ground level, m	Design Wind Speed m/sec
@ 10 M	62.81
@ 100 M	76.14

The assessment of wind loads based on the above basic wind speed shall be done as specified in IS: 875.

	b)	Wind direction	:	Predominantly W,SW,NW & SE with respect to true North
1.15	Transport		:	Rail & Road
1.16	Rail / Road access		:	About 23 km from Uklana Mandi (N. Railway) Station and NH 10 passes through Badopal village at a distance of 6 Km from site.
1.17	SEISMOLOGY		:	ZoneIII as per IS 1893-2002 part I
1.18	Auxiliary Power		:	Auxiliary electrical equipment to be supplied against this specification shall be suitable for operation on the following supply systems
	a)	For AC motors 200 kW and above	:	6600 Volts, 3 phase, 50 Hz, non-effectively earthed with following supply variations*
	b)	For AC motors below 200 kW	:	415 V, 3 phase, 3 wire, 50Hz effectively earthed with following supply variations*
	c)	Construction supply	:	415 V, 3 phase, 4 wire, 50 Hz, AC supply effectively earthed,

			one feeder supplied to the VENDOR at one point, as determined by the PURCHASER near the Sub-station, with following supply variations *
	d)	Panel Lighting fixtures, Space heaters :	240 V, 1 phase, 2 wire, 50 Hz, AC supply with neutral lead earthed, with following supply variations*
	e)	DC motors control and protective devices :	220 V, 2 wire, unearthed DC supply from Station Battery / Battery Charger, with a supply variation of (-) 20% to (+) 10% of rated voltage.
	f)	Instrumentation controls & annunciation :	i) (+) 24V DC centre tap grounded supply for general control purpose. ii) 240V AC, 1 phase, 2 wire, 50 Hz, un-interruptible power supply source (UPS).

NOTES:

1.0 *Supply Variations

i) Variation of supply voltage : (±) 10%

ii) Variation in supply frequency : (±) 5%

iii) Combined voltage and frequency variation : (±) 10%

GENERAL INFORMATION & INSTRUCTIONS TO TENDERERS

~~This specification consists of two (2) sections namely sections C & D. The sections are arranged in different volumes. These five sections con~~tain-

Section - C : Technical requirements
~~Section - D : Format for submission of part-1 (technical) of the ten~~der

All of these sections are to be read and considered together for correct understanding of scope and requirements of work to be done and interpretation of the specification.

In case of conflicting requirements specified in two different sections of this specification either the stringent one or the requirement as per PURCHASER's interpretation shall govern.

The TENDERER shall be deemed to have carefully examined the specification in its complete form and to have fully informed and satisfied himself as to the details, nature, character and quality of the work to be carried out, site conditions, seismic requirements and other pertinent matters and details.

TENDERERS are required to review tender specification and clearly state their acceptance of the same in their tenders. Deviations, if any, with respect to this specification shall be brought out **DURING SUBMISSION OF THE BID**, within the time schedule indicated by PURCHASER. Thereafter the acceptable deviation to PURCHASER will be intimated to all the bidders

The TENDERER shall certify that they have read and understood the complete specification and there are no deviations from tender specification.

~~Any deviation listed elsewhere other than the deviations listed in section D, in BID document will not be considered by PURCHASER and BID is liable to be rejected.~~

It is the intent of the PURCHASER to incorporate these documents in the final contract between the PURCHASER and the successful TENDERER. This final contract shall include deviations, if any, as mutually agreed between the PURCHASER and the successful TENDERER. However, any variation in the scope of supply to reflect the intent of this specification and to be in line with good engineering practice during execution of contract shall not be subject to price variation.

The TENDERER shall furnish all data as called for in the specification in the standard proforma to facilitate correct evaluation of tender in a most expeditious manner. It is in the interest of the TENDERER to submit the tender in the above manner failing which it is likely that tender may not be considered.

Should any doubt exist regarding any of the contents of this specification or in the interpretation of any clause, or any conflict between/within various sections of this specification, TENDERERS are invited to obtain necessary clarifications on the same before submitting their tenders. If no queries are forthcoming, the TENDERER is deemed to have understood the contents of the specification completely. In the event of any dispute regarding any of the clauses of this specification subsequent to the award of the contract the interpretation of PURCHASER is final and binding.

The TENDERER shall note that the basis of pricing and evaluation of tenders has been indicated in Section C-1-16.

Information to be included with the tender

The TENDERER shall submit all supporting information, technical data, catalogues, drawings, quality assurance manual, etc. as required in this specification, to enable the PURCHASER to make a detailed evaluation of the tender without the need for further information from the TENDERER. The TENDERER shall also submit all information/price schedules as called for in this specification.

The data, document and drawings to be submitted along with the tender documents have been listed in Sections D.

Bidder to clearly specify the sources of pipes/pipe fittings for Critical Systems / equipments like

i) Main Steam Systems.
ii) Feed Water Systems with 0.2% Cr addition
iii) Alloy Steel Piping
iv) Extraction Piping
v) Large Control Valve like CSDV, ASDV, BFP Recirculation Valve, Feed Waters Control Valves, Pegging Steam Control Valves, MSIVs, MSSVs.
vi) Boiler feed pumps, Auxiliary Boiler feed pumps and CEPs
vii) Steam turbine, Generator, Condenser and MSR

Transport Limitations

The TENDERER shall note that the equipment offered shall be suitable for delivering to site in packages of sizes and weights that are permissible under the existing road and rail limitations. The TENDERER shall be responsible for ascertaining the road and rail limitations with the concerned authorities. Responsibility of making arrangements to temporarily strengthen the roads, culverts, bridges, modification of transmission lines etc for the safe passage of equipment also lies with the CONTRACTOR

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3.1 This procurement specification covers the Design & Engineering (including optimisation studies of TG & secondary cycle), Manufacture, Procurement, Erection / Construction, commissioning & testing, trial operation, performance testing and handing over of turbine island, for two(2) nos. of 700MWe PHWR (Pressurised heavy water reactor) based nuclear power plants to be set up by Nuclear Power Corporation of India limited at Gorakhpur, Haryana. The minimum output at the generator terminals shall not be less than 700 MWe.

It may be noted that that the turbine building for the purpose of this contract shall mean the main turbine building, electrical bay of turbine building, pipe & cable bay of turbine building, access bridge from turbine building to control building and the annexes like workshop & chemical laboratory.

3.2 It is not the intent to specify completely herein all aspects of Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing, trial operation, performance testing and handing over. Nevertheless complete turbine island shall conform in all respects to high standard of Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing, trial operation, performance testing and handing over and shall be capable of continuous commercial operation in a manner acceptable to the PURCHASER who will interpret the meaning of the specifications, drawings and shall have the right to reject any work or material which in his assessment is not complete to meet the requirements of this specification and /or applicable National and / or International codes and standards mentioned elsewhere in this specification.

3.3 Whenever any material or article is specified or described by the name of a particular brand, manufacturer or trade mark, the specific item shall be understood as establishing type, function and quality desired. Other manufacturer's products may also be considered provided sufficient information is furnished so as to enable PURCHASER to determine that the products are acceptable.

Turbine Island for the purpose of this specification is defined as Turbine building & other structures included in the scope and all the equipment, system and structures required for converting the heat supplied by Nuclear Steam Supply System (NSSS) in to electrical energy. This includes the, system, structure & component required for proper functioning of the turbine generator and secondary cycle system. All the systems, structures & components required for proper functioning of these systems are deemed to be included in the specification unless specifically excluded in this specification.

CONTRACTOR shall read all the sections of this specification for completely understanding the scope of this package.

3.4 The scope of this specification includes Design & Engineering, Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over of following

1. Complete civil work of turbine building, including electrical bay, and the pipe and cable bridge between Turbine Building and pipe and cable bay of control building, outdoor transformer yard and associated tunnels & trenches within

the terminal point. Sizing and layout of Turbine Building is also included in the scope of CONTRACTOR. Structure, if required, for connecting electrical bay to above mentioned pipe and cable bridge for routing various cables & piping, in case shorter length of Turbine Building is finalised by CONTRACTOR, is also included in the scope of CONTRACTOR. The floors of the pipe and cable bridge between pipe and cable bay of control building and turbine building shall have floors matching with the floors of the pipe and cable bay of control building. Suitable Fire rated wall along the Electrical bay side shall be provided by the CONTRACTOR. Apart from the access from the PC bay of control building there is requirement specified for access from control building. This requirement is marked in the sketch No. GHAVP-1&2/29700/2001/SK attached with this tender. The location and dimension of the above access shall be finalised by the contractor based on actual location and size of turbine building finalised by contractor.

The rail track as shown in the attached drawing and its erection for the movement of generator transformer from the location of generator transformer area to turbine building unloading bay is also included in the scope of contractor. Culvert shall be provided for the rail at the location where it is crossing over the condenser cooling water lines to protect the condenser cooling water lines from the load of the generator transformer.

2. Complete Secondary Cycle System including the Turbine Generator Plant (TGP) comprising of Steam Turbines, Generator, Moisture Separator and Re-heater and Condenser.

   It also includes, procurement, construction and erection of Structural steel platforms in Reactor Building (RB) for O&M and in-service inspection, in Station Auxiliary Building for handling and maintenance of Auxiliary Condensate Storage Tank and in PC bay for handling, dismantling and maintenance of Atmospheric steam discharge valves (ASDVs), Pilot operated main steam safety valves (POMSSVs), Main steam isolation valves (MSIVs), Main feed isolation valves (MFIVs), Auxiliary feed water system (AFWS) Control valve (CV) station. Following drawings indicating the sizes of platforms (length, width and height) for above systems / equipment are attached:

   a) GHAVP-1/40000/2001/SK-For MSIVs, ASDVs and POMSSVs.
   b) GHAVP-1&2/40000/2004/SK-For CV station of AFWS and for MFIVs.
   c) GHAVP-1&2/40000/2005/SK-For secondary cycle piping inside RB between grids BZ & CZ at elevations 123000, 125300 and 127300.
   d) GHAVP-1&2/40000/2006/SK-For secondary cycle piping inside RB between grids AZ1 & BZ at elevations 123000, 125300 and 127300.

   The above platforms are required for both the units.

3. Complete Electrical Power Supply & Distribution System required for turbine island, as specified in section C-2-3 of this specification. Contractor shall note the requirement of supporting the power conductors of GT from gantry tower to be erected in transformer yard. The foundation of this gantry tower and the fabrication & erection of this gantry tower is also in the scope of TIP

contractor.

4. All water systems required inside turbine building such as Condenser cooling water, Demineralised (DM) water, auxiliary cooling water, auxiliary service water, fresh water, domestic water, firewater & chilled water, fire detection and fire protection system etc.

   Condenser cooling water, DM water, fire water, chilled water & auxiliary service water will be provided by PURCHASER at one terminal point as shown in the enclosed sketch.

5. Complete control and instrumentation system required for all systems included in the scope of turbine island.

6. Complete ventilation system of turbine building. Compressed air requirement of systems inside turbine building. Compressed air (instrument air and service air) required for system operation will be supplied at one location near turbine building by PURCHASER.

7. Non active drainage system of turbine island including plant drains and storm water drain.

8. Material handling systems required inside turbine building e.g. Electric Overhead Travelling (EOT), Hand Operated Trolley (HOT), monorails. Elevators (minimum 2 numbers -1big for material & personnel and 1 small for personnel) for movement of personnel and material, etc. Similarly one big elevator for material and personnel is to be provided in electrical bay. All equipment shall be provided with suitable handling arrangement. Monorails for equipment located inside pipe and cable bay in control building is also included in CONTRACTOR's scope. Two EOT cranes shall be provided in turbine hall. One EOT crane shall have the main hook with the capacity to handle the single heaviest component of turbine generator set (other than generator stator) and an auxiliary hook of 25 Ton capacity. The main hook shall be designed for 110% of the weight of the single heaviest component or 125 tonnes whichever is higher. The other EOT crane shall have the capacity of 25 Tonnes. TB hall EOT crane span shall be equal to TB hall width and travel shall cover complete length of TB including unloading bay. EOT crane capacity shall be adequate to handle the heaviest single part of TG except Generator Stator. Turbine generator centreline and location with reference to site grid lines shall match with that shown in the drawing. EOT crane span shall be such that it is able to handle the equipment located inside turbine building. Two cranes shall be able to handle independent loads at the same time. Two cranes are not envisaged to handle single load together.

   One more EOT crane is required for handling boiler feed pump in boiler feed pump area.
   10T double girder under slung EOT crane shall be provided in the workshop shop area.

Handling arrangements for large valves like CCW butterfly valves, large MVs of Extraction steam systems shall also be provided by Bidder.
Requirements of material handling systems for Turbine island package shall be as per the requirement of specification for EOT cranes enclosed with the tender. Based on these requirements bidders shall finalize the specification of material handling systems required in turbine building. The cranes covered in this package shall be operated and maintained by TIP contractor till the handing over of the systems to purchaser.

9. Turbine oil storage tank (TOST):- A fabricated tank of around 60m^3 capacity shall be supplied by contractor. This tank i.e. turbine oil storage tank will be used for lube oil storage and for receiving the oil during filling up.

   All connections, pump, inter-connecting piping for purifying the oil in the storage tank and pumping it to main oil tank shall be provided. Also an unloading funnel at operating floor or any other higher level floors & filling line shall be provided for filling up the TOST by unloading the oil barrels.

10. Complete fire protection system for turbine building including turbine oil tanks and generator bearings in case the generator bearings are located outboard.

11. For Main steam, feed water and steam generator blow down piping the dynamic analysis is required to be carried out for the portion of piping from anchor on pipe and cable bay to first anchor in turbine building.

12. The room for locating H_2 and CO_2 Cylinders shall be provided by the CONTRACTOR in turbine building in such a way that the room is isolated from turbine building by concrete walls and entry & exit are from outside of turbine building.

13. Flash tanks are included in the scope of TIP. Separate flash tanks shall be used for high pressure, low pressure, critical turbine & main steam drains and start-up drains. These are in addition to steam generator blow down flash tank.

14. Main steam (MS), Main Feed water (MFW), Auxiliary feed water (AFW) and Steam generator blow down (SGBD) piping are having penetration bellows on RB containment. FW Piping is having penetration bellows on RAB-CB interface and within RAB also. SGBD Piping is having penetration bellows on RAB. These are shown in drawing attached with this tender (GHAVP-1&2/40009/2001/SK (7 sheets) (Refer section C-2-2-13)). CONTRACTOR shall note that all these bellows are in the scope of TIP. The nearest pipe support structure to the bellows shall be sufficiently away from the bellows assembly such that it doesn't interfere with the bellows movement under all levels of loading and also to facilitate in-service

inspection of both the bellows and the support structures without any difficulty.

PURCHASER has carried out certain engineering activities related to safety class 2 portion of the secondary cycle system. (Refer section C-2-2-1)

15 Fire Hazard Analysis (FHA) of turbine building will be carried out by purchaser. Ratings are based on following considerations.

- All the Structures and components that form the compartment envelope shall have fire rating as stated.
- Containment envelope includes walls, ceiling ventilation dampers, doors and cable penetration seals. Vision panels in fire doors, wherever used shall be of the same rating as the doors.
- In case, a structure/component is shared between two compartments, then the rating of that structure/component is governed by maximum of the two estimated ratings.

Estimated and recommended ratings of Turbine Building

S.No.	Area	Required Rating
1	Various pits where pumps are located eg. MSDP, LPHDP or any other pump	60 min
2	Condensate Extraction Pump & Heat Exchanger Area	60 min
3	Generator seal oil unit area	90 min
4	Dry panel room (SWAS room)	60 min
5	Wet panel room (SWAS room)	60 min
6	H_2/CO_2 gas cylinder room	60 min
7	Open turbine building hall at all Elevations	60 min
8	Turbine oil storage tank room	180 min + active suppression
9	Lube oil room	180 min + active suppression
10	Turbine building annex building rooms and inside annex building	60 min
11	Battery Room	60 min
12	UPS Charger Room	60 min
13	AHU Room	60 min
14	Cable Spreader Room	60 min
15	Local Control room inside turbine building	60 min
16	Air Washer Plant	60 min

The above ratings are with assumption that lubricating oil for turbine generator & other equipment like BFP is mineral oil. Control fluid for turbine generator is fire resistance fluid and all cables are FRLS cables.

TBEB FIRE RATINGS

Ratings are based on following considerations.

- All the Structures and components that form the compartment envelope shall have fire rating as stated. (Refer Sec.3.2.4 of AERB Safety Standard No. AERB/NF/SS/FPS (Rev.1) "FIRE PROTECTION SYSTEMS FOR NUCLEAR FACILITIES")
- Containment envelop includes walls, ceiling ventilation dampers, doors and cable penetration seals. Vision panels in fire doors, wherever used shall be of the same rating as the doors.
- In case, a structure/component is shared between two compartments, then the rating of that structure/component is governed by maximum of the two estimated ratings.

Floor EL (M)	Room No	Room	Required Rating
95.5	TBE-101	Cable gallery	60 min
95.5	TBE-101	Cable shaft	60 min
100	TBE-201	Div-I 415v Swgr Room	60 min
100	TBE-202	Div-Ii 415v Swgr Room	60 min
100	TBE-203	Passage	60 min
100	TBE-204	Cable shaft	60 min
105.3	TBE-301	Cable gallery Div-I	60 min
105.3	TBE-302	Cable gallery Div-Ii	60 min
105.3	TBE-303	Passage	60 min
105.3	TBE-304	Cable shaft	120 min
105.3	TBE-305	Cable bridge	60 min
111	TBE-401	Div-I 6.6 Kv Swgr room	60 min
111	TBE-402	Div-Ii 6.6 Kv Swgr room	60 min
111	TBE-403	Passage	60 min
111	TBE-404	Cable shaft	60 min
118	TBE-501	Cable gallery Div-I	60 min
118	TBE-502	Cable gallery Div-Ii	60 min
118	TBE-503	Passage	60 min
118	TBE-504	Cable shaft	60 min
122	TBE-601	Div-I 415v Mcc room	60 min
122	TBE-602	Div-Ii 415v Mcc room	60 min
122	TBE-603	Passage	60 min
122	TBE-604	Cable shaft	60 min
126.5	TBE-701	Escada room	60 min
126.5	TBE-702	Ahu room	60 min
126.5	TBE-703	Passage	60 min
126.5	TBE-704	Cable shaft	60 min

All the remaining structures shall have the rating of 60mins.

16. Piping analysis of all other piping system which are under the scope of this package is in CONTRACTOR's scope.

17. A workshop (common for both units-1&2) shall be provided in one turbine building (Unit-1) annexe with adequate area to accommodate the machines, tools crib, oil room, valve testing facility and welding shop etc. Details of machines to be accommodated in workshop have been given in other sections of this specification. Layout for this workshop is also enclosed Detailing required for execution of work is in CONTRACTOR's scope. Material handling arrangement for workshop is also included in contractor's scope. Separate overhead handling facility for welding shop and machine shop is required.

18. Chemical laboratory (common for both units-1&2) for analysis of steam, water, lubricating oil etc. of the plant shall be provided in other turbine building (Unit-2) annexe where workshop is not provided. Chemical laboratory shall be air conditioned. Earmarked area in the plant layout drawing shall be utilised for constructing chemical laboratory. Layout of chemical laboratory will be provided to successful bidder.

Detailed scope is included in chapters C-2-1, C-2-2, C-2-3, C-2-4, C-2-5, C-2-6 and also shown in drawings enclosed with this specification.

3.5 Quality assurance activities for Design & Engineering, Procurement, Erection / Construction, commissioning & testing, trial operation, performance testing and handing over are included in the scope of work.

3.6 Preparation and submission of all the drawings and documents for all system structures and equipments such as concept notes, design basis reports, optimisation studies, design calculations, design drawings, specifications, erection drawings, equipment drawings, erection procedures, commissioning & testing procedures, commissioning reports, design manuals, operating procedures including operating drawings, operation and maintenance manuals, history dockets, pre-service / in-service inspection document, collecting pre-service inspection data,

3.7 Supporting purchaser for interaction with regulatory authorities, in responding to queries raised by regulatory authorities, attending any technical discussion with regulatory authorities, if required.

3.8 Training of purchaser's personnel for operation and maintenance of system, structure and equipment.

3.9 For the heat exchangers of liquid ring vacuum pump of condenser, Auxiliary service water (ASW) shall be used.

3.10 Valve actuators of Motor operated valves located outside the reactor building containment need not be qualified for radiation.

3.11 Intelligent P&IDs shall be prepared by CONTRACTOR.

3.12 Floor response spectra for the various floors of turbine building as per BIS 1893 shall be worked out and submitted by the CONTRACTOR.
Turbine building layout and design shall ensure compliance to the Atomic Energy Regulatory Board's (AERB) "Atomic energy (Factories) rules -1996" and "AERB safety standard no. AERB/NF/SS/FPS (Rev.1) – Fire protection system for nuclear facilities".

3.13 Air conditioning of the Control room made above the workshop / chemical laboratory in turbine building annexe shall be capable of maintaining the temperature of 18^0C inside the rooms. For air-conditioning of control room as a backup, separate VCM chillers / package air conditioning unit shall be provided.

3.14 **Design & Engineering-** Scope covers from conceptual design to design finalisation, detailed engineering and preparation of drawing, documents and specification etc. Design and engineering includes but not limited to, development of design basis, studies of various alternatives and selection of suitable alternative, preparation of design basis reports, concept notes, equipment / piping design philosophy, design / sizing criteria, optimization studies, design calculation, design parameters finalisation, preparation of Process and Instrumentation Diagrams (PIDs), development and finalization of control and logic requirements, redundancy & design margins requirements and material selection of various system, equipment and piping, preparation of layout drawings, equipment foundation design, isometric drawings, various schedules, design manuals for each system structure and component for complete turbine island systems. If any new design is used then design verification and validation shall be carried out by CONTRACTOR. The required numbers of embedded parts shall be designed, manufactured, fabricated and erected in the turbine building and for electrical bay the same shall be fabricated and erected by the TIP contractor for system, structure and equipment erection. The EPs inside electrical bay will be designed by the purchaser and its fabrication drawings also be issued by purchaser.

Scope includes three dimensional modelling and engineering of complete turbine building, electrical bay of turbine building, workshop and chemical laboratory in turbine building annexe buildings, extended PCB, transformer yard area including all system inside turbine building, as included in scope of this package, in integrated engineering environment. The systems inside electrical bay like fire water piping, ventilation ducts, cable trays etc, though not in the scope of contractor, shall be modelled inside electrical bay. The inputs for these systems for modelling would be provided by purchaser. Similarly in the transformer yard area, apart from, tunnel & trenches and transformer foundations & pits that are in the scope of contractor, modelling of transformers (though transformers are not in the scope of contractor) also is included contractor's scope. Following deliverables shall be taken only from integrated engineering environment.

(a) Intelligent P&ID.

(b) Piping material specification.
(c) Pipe line reference list PLRL.
(d) Equipment list.
(e) Valve list.
(f) Line mounted equipment / instrument list.
(g) GA drawing plan & Sections (TB Equipment layout and piping). Sectional views to be provided for overlapping components.
(h) Isometric drawings for each line number.
(i) BOQ.
(j) Schedule for valves, equipments, instruments, cable trays, ducting.
(k) Support schedules.
(l) Support drawing, along with BOM.
(m) EP list.
(n) Insulation schedule.
(o) Inputs for piping flexibility / stress analysis shall also be taken from Integrated 3D Model.
(p) As built drawing shall also be made on Integrated 3D Model.

All deliverables to be generated for erection purpose and otherwise shall be generated from this integrated engineering environment. CONTRACTOR shall use the latest version of CADMATIC for 3-dimensional modelling. While carrying out three-dimensional modelling and engineering CONTRACTOR shall use the same symbols for all components as used by PURCHASER. List of symbols used by PURCHASER will be given to successful bidder. CONTRACTOR shall provide an editable copy of 3D model in CADMATIC with administrative password on completion of TIP package.

The CONTRACTOR shall prepare "As Built drawings" separately after completion of each system on 3D Model. All the "As built drawings" shall be extracted from 3D model and the electronic form shall be submitted for PURCHASER's approval. The cost towards the same is deemed to be included in the price quoted in the summary price schedule.

3.15 **Procurement-** Invitation of bids for bought out items based on specifications prepared, bid evaluation, preparation of purchase recommendation, placement of order, review of drawings and documents, quality surveillance during manufacture, witnessing non destructive testing and performance testing of equipment at manufacturer's works, packing, supply, ocean shipment and marine insurance and clearance through Indian port of entry in case of imported plant and equipment, inland transportation, inland transit insurance, delivery to site, unloading, taking delivery, site storage, receiving all the drawings and documents form vendor, preservation during transit & storage.

Transportation of over dimensional consignments shall be planned by CONTRACTOR well in advance and any limitation shall be taken care of. All arrangements and procedures of transportation of over dimensional consignments from works to site are in scope of CONTRACTOR. Responsibility of making arrangements to temporarily strengthen the roads, culverts, bridges, modification of transmission lines etc for the safe passage of equipment also lies with the CONTRACTOR.

3.16 **Manufacture-** Manufacture of the equipment covering all activities from material induction, manufacturing process, quality surveillance, inspection and testing, packaging & transportation to site receipt of equipment at PURCHASER's site, are covered in the scope. Scope covers review of drawings and documents, quality surveillance during manufacture, witnessing non-destructive testing and performance testing of equipment at manufacturer's works, packing, supply, ocean shipment and marine insurance and clearance through Indian port of entry in case of imported plant and equipment, inland transportation, inland transit insurance, delivery to site, unloading taking delivery, site storage at site till erection.

Transportation of over dimensional consignments shall be planned by CONTRACTOR well in advance and any limitation shall be taken care of. All arrangements of transportation of over dimensional consignments from works to site are in scope of CONTRACTOR.

3.17 **Erection / Construction-** Scope of erection and construction covers material handling during erection/construction, transportation from storage to erection site, testing before erection, complete erection, site testing after erection, identification and development of erection & construction procedures for all equipment, structures and systems of turbine island as specified herein. Erection and construction of all systems, equipment and structures of turbine island in such a manner so as to render the system complete for safe & efficient operation of the plant. Preparation of as built drawings for all systems, including field routed piping. Preparation of construction completion reports. Collection of all base line data of erection. Collection and documentation of pre-service inspection data of ultrasonic examination of weld joints of safety class II piping and equipment. Collection and documentation of UT thickness gauging data for continuous monitoring of high energy piping for flow accelerated corrosion.

3.18 **Commissioning & testing**- Scope of commissioning & testing include preparation of detailed logical and sequential programme of commissioning activities, commissioning procedures. Commissioning of all the system, structure and equipment to verify the design intent, preparation of commissioning reports. Carryout any modification required in the system, structure and equipment based on commissioning feedback. Preparation of operation and maintenance manuals for all systems, equipment and structures. Preparation of history dockets for all systems equipment and piping system. Development and preparation of operating procedures & operating flow-sheets. Performance testing of complete turbine generator and secondary cycle system and all other systems included in the scope of turbine island. CONTRACTOR shall impart training on PURCHASER's operating personnel to become familiar with operating characteristics and maintenance aspects of the plant.

3.19 **Trial operation and handing over & performance testing** - Scope of trial operation and handing over includes carrying out the performance test of complete turbine island plant, operation of the plant as per the operating procedures along with the PURCHASER's personnel and resolving any problem observed during trial operation and carryout any modification in system, structure and equipment required based on the feed back of trial operation. Handing over system structure and equipment along with all

the drawings and documents to purchaser to the satisfaction of purchaser.
CONTRACTOR shall note that performance test of turbine generator and secondary cycle shall be carried out for one unit only i.e. for GHAVP-2.

3.20 CONTRACTOR shall give the equipment, piping, supports, specialities, instruments etc. tag numbers according to PURCHASER's tag numbering system as per Universal Subject Index (USI) system of PURCHASER. These tag numbers will be in addition to tag numbers given by CONTRACTOR and individual equipment vendor. Tag numbers of PURCHASER as well as CONTRACTOR shall appear on all drawings and documents and shall be put on the equipment and items also.

3.21 CONTRACTOR shall submit soft copies (in Autocad, MS office) of all drawings and documents to PURCHASER in addition to hard copies.

3.22 CONTRACTOR shall make all the necessary provisions for installation of instruments required for performance testing of turbine cycle.

3.23 All softwares used by CONTRACTOR for executing the contract shall be of latest version of internationally accepted, widely used and available in the market. In case CONTRACTOR prefers to use any other software the same is also acceptable provided proper validation is carried out and the licensed copy of the software is also be supplied to PURCHASER without limitation of time duration for purchaser's use.

All softwares to be used in process control, logics and protections shall be properly verified and validated. Detailed procedures for all softwares (For design & engineering as well as control and instrumentation purpose) validation shall be submitted for approval. After completion of validation, validation report shall also be submitted to PURCHASER.

3.24 Safety and security during storage, transit, erection till it is finally handed over to PURCHASER. Ensure safety of other system structures and components in the vicinity of area of work.

The following services would be arranged by PURCHASER.

PURCHASER has carried out following activities on the systems mentioned below

Main steam system:- PURCHASER has carried out the pipe line sizing, piping layout from steam generators up to pipe anchor on pipe and cable bay in control building, finalised the capacity of atmospheric steam discharge valve and main steam safety valves in terms of percentage of the total steam flow at 100% full reactor power and sizing of main steam isolation valve for main steam system.

Feed water system:- Pipe line sizing, piping layout from steam generators up to pipe anchor on pipe and cable bay in control building, sizing of containment isolation valves.

Steam generator blowdown system:- Pipe line sizing, piping layout from steam generators up to pipe anchor on pipe and cable bay in control building, sizing of containment isolation valves.
The layout of the alternate path to transport the blowdown to waste management plant, in case high radioactivity is detected.

Auxiliary feed water system:- Pipe line sizing, piping layout, equipment layout sizing of containment isolation valves in pipe and cable bay in control building. Capacity of auxiliary feed water storage tank is finalised by PURCHASER. ABFP flow is finalised by PURCHASER, however the total developed head of pump shall be finalised by CONTRACTOR based on the de-aerator pressure at 100% power operation and 0% full power operation.

Auxiliary steam and condensate system:- Pipe line sizing & piping layout in pipe and cable bay in control building, RAB, & waste management plant (WMP), of the steam supply and condensate return lines for Vapour bsorption Machine (VAM) chillers (in basement of control building), WMP and D_2O upgrading plant.

The layout of above piping (safety class 2 portion of main steam, main feed water, SGBD and auxiliary feed water system are enclosed with the tender.

PURCHASER will also carry out the piping analysis and support design of the below listed portion of the secondary cycle system:

a) Part of main steam, main feed water and steam generator blow down piping from steam generator up to anchor on pipe and cable bay in control building.
b) Auxiliary steam and condensate lines (for VAM chillers and D_2O upgrading plant & waste management plant (WMP)) with in pipe and cable bay of

control building, RAB & WMP. However complete design & engineering of this piping from the tapping point within turbine building up to anchor (on PC bay of control building) is in the scope of contractor.

c) Complete piping of auxiliary feed water system including the piping from de-aerator to ABFP suction down stream of pipe anchor on pipe and cable bay in control building up to ABFP. However complete design and engineering of ABFP suction piping from de-aerator up to anchor (on PC bay in control building) shall be carried out by CONTRACTOR. Similarly, the recirculation line from pipe anchor (on PC bay of control building) to De-aerator is in the scope of CONTRACTOR. For details of scope of Auxiliary Feed Water system refer sketch of the auxiliary feed water system enclosed with the tender.
d) The alternate path of SGBD blown from anchor (on PC bay of control building) to waste management plant. However, complete design and engineering of this piping up to anchor (on PC bay of control building) is in the scope of contractor.

The above-mentioned design and engineering activities are the only activities related to design and engineering which are carried out by PURCHASER. All other activities of Design & Engineering, Manufacture, Procurement, quality surveillance, Erection / Construction, commissioning & testing, trial operation, performance testing and handing over are included in the scope of CONTRACTOR. Contractor shall note that the support structures, anchor structure, whip restraints, limit stops etc in the above portion of piping being engineered by purchaser shall be manufactured, supplied and erected by contractor.

The detailed drawings of all the supports, anchors, whip restraints designed by purchaser as mentioned above will be furnished by the purchaser to the successful bidder. However for the estimation and understanding the scope of procurement, erection and commissioning of these structures, details of such supports of the previous 700 MWe project is enclosed with the tender.

Public address systems are excluded from the scope of the CONTRACTOR. The same will be engineered and implemented by PURCHASER. However, CONTRACTOR shall co-operate with the PURCHASER/other Contractor for carrying out the engineering, procurement, construction & commissioning of these system inside turbine building, PC bay and Electrical bay.

Independent fire detection and protection system required inside turbine building, PC bay and Electrical bay is in the scope of this package.

Control power supply of 220V DC, 24V DC and 240V AC will be made available at one point by PURCHASER for implementation of C&I of the systems.

Design, supply, installation of all switchgear, panels, SCADA, protection panels,

MCCs (other than those included in this tender), auxiliary transformers in electrical bay & power transformers in transformer yard, supply and installation of cabling from equipment not supplied by the CONTRACTOR, supply and installation of cabling from equipment supplied by the CONTRACTOR but not covered under the scope defined in section C-2-3-1 are excluded.

Crawler crane will be provided by purchaser free of charge for the erection of Generator stator and Moisture -Separator-Re-heater (MSR).

Cylinders of CO_2, N_2, and H_2 are not in the scope of CONTRACTOR.

Chemical Laboratory instruments, hardware, reagents etc. are not in the scope of CONTRACTOR.

Machines for mechanical workshop are not in the scope of contractor.

The above-mentioned activities/services are the only activities/services carried out/provided by PURCHASER.

5.0 FREE ISSUE OF MATERIALS & SERVICES

NIL

There is no material which is free issue to the contractor. All material required for completion of scope of work is included in the scope of contractor, so as to render the plant complete and fully functional in safe reliable and satisfactory manner.

Control power supply of 220V DC, 24V DC and 240V AC will be made available for implementation of C&I of the systems.

Other services provided by PURCHASER are identified in individual chapters of Section C-2

6.0 OPTION FOR PLACEMENT OF ORDER

6.1 PURCHASER reserves the right to place order for all items listed in the specification or for a part there of at his discretion. No revision of prices or conditions will be entertained by PURCHASER arising due to award of work in part for whatsoever reasons.

6.2 PURCHASER reserves the right to accept or reject the lowest or any bid, without assigning any reason for the rejection of the bid and without purchasing the whole of the plant specified.

6.3 CONTRACTOR shall submit the bids as per this specification. If the CONTRACTOR wants to submit the offer which is at variance with the specification and in his opinion better and covers the complete scope of work, he may do so by submitting the alternate offer in addition to one offer as per this specification. However PURCHASER reserves the right to accept or reject such alternate offers.

Terminal points for various systems are as given below

7.1 **For civil works-Refer chapter C-2-1**

7.2 **For turbine generator and secondary cycle system**- Terminal point for supply, erection, commissioning, testing, trial operation for main steam system, feed water system, steam generator blow down system and auxiliary feed water system is steam generator nozzles. Welding of piping with steam generator nozzles at terminal point is in the scope of contractor. Refer chapter C-2-2-5 for other terminal points.

7.3 Electrical systems-:

7.3.1 IPBD:

IPBD: Terminals of unit transformers and generator transformers in transformer yard. **For details refer chapter C-2-3.**

7.3.2 Other terminal points related to Electrical system are covered in Section C-2-3

7.4 Control and instrumentation and control system- Refer chapter C-2-4

7.5 Water systems- Refer chapter C-2-5

7.6 Air conditioning, ventilation and compressed air system-Refer chapter C-2-6

8.1 INTRODUCTION

Complete plant layout is shown in drawing number GHAVP-1,2/10000/5001/GA. Bidder shall note the area earmarked for turbine building and electrical bay of turbine building. Bidder shall also note the location of heavy water upgrading plant and demineralised water plant particularly. PURCHASER has planned supply of main steam to heavy water upgrading plant, waste management plant, vapour absorption machine (VAM) chiller etc. In case the blowdown is contaminated the same needs to be transported to storage facility located in waste management plant. This is also included in the scope of CONTRACTOR. CONTRACTOR shall note the location of last stage of first low pressure turbine from reactor building, marked in this layout drawing and turbine missile envelop. CONTRACTOR shall locate the low pressure turbines in such a manner that envelop of turbine missile will not cover any safety related structure. Any limitation to meet this requirement shall be clearly brought out in the offer by CONTRACTOR. CONTRACTOR shall note that pipe and cable bridge between pipe and cable bay and turbine building is also in the scope of CONTRACTOR. CONTRACTOR shall provide stair case to access all the floors in pipe and cable bridge which is in CONTRACTOR's scope. CONTRACTOR shall also note the location of station auxiliary building and location of auxiliary condensate storage tank at the roof of this building (121m EL). CONTRACTOR shall also note that hydrogen and carbon dioxide cylinder room for turbo generator shall be located outside turbine building in a fire rated enclosure.

CONTRACTOR shall note that as per AERB safety guide No. AERB/NPP-PHWR/SG/D-1 " Safety classification and seismic categorisation for structures, systems and components of pressurised heavy water reactor." Though the turbine building seismic category is 3, which means turbine building may follow national practice; and can be designed and built as per IS-1893. However it is possible that turbine building, as a result of earthquake, will jeopardise the System Structure & Components (SSCs) in a higher category due to collapse, falling or any other spatial interaction. Therefore turbine building should be determined by analysis, test or experience and classified in the same category as the endangered SSCs i.e. seismic category-1; or the absence of collapse, shall be demonstrated under the reference ground motion. It is CONTRACTOR's responsibility to design and demonstrate the turbine building as required by AERB safety guide.

CONTRACTOR shall note that Mechanical workshop facility for maintenance purpose shall be provided in turbine building annexe ground floor.

All entry and exit points in turbine building including the fire escape routes shall be as per National/International standards and considering all industrial safety norms, including that of AERB rules.

The configuration of the turbine generator and secondary cycle system described here is representative. The actual cycle configuration & equipment parameters, turbine generator and auxiliary details shall be finalized by CONTRACTOR. However for part of

main steam system, feed water system, steam generator blow down system and auxiliary feed water system sizing and piping layout have been finalised by PURCHASER. However the Manufacture, Procurement, Erection / Construction, commissioning & testing, trial operation and handing over of this part is also included in CONTRACTOR's scope.

The turbine generator and secondary cycle system shall cover the Turbine generator and auxiliary systems, Main Steam System, Steam Generator Blow Down System, Chemical feed system, Steam & Condensate System for heavy water upgrading and waste management plant, Mass and Alkaline flushing system for main steam and secondary cycle piping / pre operational cleaning system, Moisture Separator Drain System, Reheater Drain System, Gland Steam System, Turbine lube oil storage & purification System, Steam Dump (to condenser) System, Extraction Steam System, Heater Drain System, Heater Vent System, Feed water System, Condensate System, condenser air evacuation system, On load condenser tube cleaning system, Gland Sealing System, Auxiliary Feed Water System, Makeup Water System, Sampling System, Steam Drain System along with their controls and protective systems.

Steam from the steam generators is led to a double flow high pressure (HP) turbine. Exhaust of high pressure turbine is led to combined moisture separator and reheater (MSR). In MSR moisture is removed from the exhaust steam and reheating is done in two stages. First stage reheating is done with bled steam from the high pressure turbine and second stage reheating is done with live steam. After reheating, steam expands in of double flow low pressure (LP) turbines. Exhaust steam from low pressure turbines is condensed in condensers. One condenser is provided for each low pressure turbine. Condensate from condenser hotwell is pumped by condensate extraction pumps (CEPs), through gland steam condenser and stages of low pressure feed water heaters to deaerator. Boiler feed pumps (BFPs) take suction from deaerator and pump the feed water through stage/stages of high pressure feed water heaters and feed water control station to steam generators.

The section of piping from the steam generators up to and including main steam isolation valves (MSIVs) perform safety function. An alternate source of feed water has been provided for decay heat removal from reactor in case of non- availability of main feed water. This system is important for safety and hence the auxiliary feed water system (AFWS) consisting of auxiliary condensate storage tank (ACST), auxiliary boiler feed pumps (ABFPs), associated piping, control valves, instrumentation, is classified as safety system. The rest of the systems namely piping from downstream of MSIVs to turbine, emergency stop and control valve, moisture separator and reheater, condenser, condensate extraction pumps, feed water heaters, deaerator, boiler feed pumps and generator are Not Important to Nuclear Safety (NINS) Systems. Details of various control and protective systems for the turbine are typical of a particular turbine vendor.

8.2 TURBINE CYCLE

3874 tones/hr of 0.25% wet steam at 44 kg/cm^2 (g) is delivered by steam generator to the turbine with a feed water inlet temperature to steam generators 181.2 deg C. Steam pressure remains constant from 0% full power to 100% full power of reactor. Steam from HP cylinder exhaust passes through moisture separators and re-heaters before entering LP cylinders. The steam from LP Cylinders exhaust to surface condensers. Cooling water system is open recirculation type with natural draft cooling towers. The makeup for the condenser cooling water system will be supplied from lake. (Note: Steam flow depends on final feed water temperature; therefore these values may change slightly based on offered optimised turbine cycle)

The condensate is extracted from condenser by three 50% capacity condensate extraction pumps (CEPs). The condensate passes through gland steam condenser and stages of LP feed water heaters to the deaerator.

Three 50% capacity boiler feed pumps take suction from deaerator and pump feed water into the steam generators through stage/stages of HP feed water heater and feed water control station.

The 3 phase electrical generator rotor is hydrogen cooled. The stator winding is constructed of hollow and solid copper conductors. Through hollow copper conductors cooling water at a pressure lower than hydrogen pressure is circulated for removing heat from stator winding.

CONTRACTOR shall indicate the maximum continuous rating and power generation capability under valves wide open conditions of the plant considering the above conditions.

For design of turbine island following inputs and interfaces shall be considered –

a. The area earmarked for turbine building in plant layout is shown in drawing GHAVP-1,2/10000/5001/GA. Depending upon the size of turbine building CONTRACTOR shall utilise the area. While finalising the turbine building size and location with reference to reactor building CONTRACTOR shall note the required location of turbine centreline (longitudinal axis) and location of last stage (nearer to HP turbine) of first low pressure turbine from reactor building. This is marked in the layout drawing. Low pressure turbines shall be so located that turbine missile envelop shown on drawing shall not extend towards any safety related structure. Any limitation to meet this requirement shall be clearly brought out in the offer by CONTRACTOR. CONTRACTOR shall also note that depending upon size and location of turbine building a pipe and Cable Bridge will be required between pipe and cable bay of control building and turbine building. This pipe and cable bridge is also in the scope of CONTRACTOR. Turbine building civil requirements are detailed out in

chapter- C-2-1. Main steam, feed water, auxiliary feed water and steam generator blow down piping, Electrical power cables trays, and control and instrumentation cable trays from reactor building to turbine building are routed over pipe and cable bay of control building. These pipes and cables will enter turbine building from various floor elevations from pipe and cable bay of control building. CONTRACTOR shall note the various floor elevations of pipe and cable bay and elevations at which Main steam, feed water, auxiliary feed water, steam generator blow down piping, Electrical and control and instrumentation cable trays will be routed between turbine building and pipe and cable bay of control building. CONTRACTOR shall confirm his acceptance of these elevations in his offer. Further routing of the pipes and cables inside turbine building, from these elevations in pipe and cable bay, shall be carried out by CONTRACTOR.

While carrying out the layout of the system in turbine building CONTRACTOR shall ensure that adequate space (with adequate load bearing capability) for lay down of equipment for operation and maintenance, pump rotor pull out space, feed water heaters / heat exchanger tube/shell pull out space, equipment movement paths for erection and subsequent maintenance shall be provided. Space shall be adequate around the equipment for carrying out maintenance activities and any inspection during operation. Equipment movement paths and equipment laydown areas shall be clearly marked on the drawings. Adequacy of space with reference to all above aspects shall also be demonstrated in three dimensional modelling of the system carried out in integrated engineering environment. CONTRACTOR shall specifically confirm this aspect.

b. 3874 tones/hr of 0.25% wet steam at 44 kg/cm^2 (g) delivered by steam generator to the turbine with a feed water inlet temperature of 181.2 deg C. Steam pressure remains constant from 0% full power to 100% full power of reactor. Requirements are detailed out in section C-2-2. Steam generator pressure is maintained at 44.0 Kg/cm2 (g) by steam generator pressure control program. Steam generator pressure control is achieved by controlling turbine governor valves, condenser steam dump valves and atmosphere steam discharge valves. Steam generator level control is carried out by modulating feed water control valves.

c. Condenser cooling water from natural draft cooling towers at temperature varying from 32 to 36 degrees centigrade(to be optimised by contractor).

d. Cooling of turbine generator and auxiliaries located inside turbine building is with two cooling water loops. First is a closed loop cooling water system called Auxiliary cooling water (ACW) system, this system in turn

will be cooled by Auxiliary service water (ASW) system. Cooling water for ASW will be supplied from natural draft cooling tower at one terminal point out side turbine building. Design of both ACW & ASW systems inside turbine building is in scope of CONTRACTOR. Total requirement of ASW shall be finalised by CONTRACTOR within six months from the date of placement of order and communicated to PURCHASER.

e. All other water systems such as demineralised water, fire water, domestic water, chilled water will be provided at one terminal point outside turbine building. Further engineering of this system inside turbine building is in scope of CONTRACTOR. Cooling water system requirements are detailed out in chapter- C-2-5.

f. Description of Electrical systems is covered in detailed in chapter C-2-3.

g. Control & instrumentation requirements are detailed out in chapter C-2-4.

h. Turbine building ventilation requirements are covered in chapter C-2-6.

8.3 POWER SUPPLY

Power generated by the turbo generator is delivered to the low voltage windings of generator transformers through Isolated Phase Bus Duct (IPBD) and Generator Circuit Breaker. Generator may have brush less excitation system or static excitation system as per the specification. The generator transformer steps up the voltage to 400kV which is the transmission voltage. The unit auxiliary loads are provided with power supplies from (1) Start-up transformer and (2) Unit transformers located in the transformer yard just out side the turbine building.

PURCHASER has classified the power supplies in complete plant as given below and made provisions for electrical power supply requirements of the CONTRACTOR. CONTRACTOR shall note the limitations in the power that can be drawn from these supplies and make suitable design provisions. Further, these power supplies are available to the CONTRACTOR at terminal points identified in Chapter C-2-3-7.

Class-IV AC Supply: Source of supply derived from the main generator and from off-site sources. Power supply to the Class IV buses can be interrupted for any prolonged hours whenever there is a simultaneous power supply failure from the grid as well the station main turbo-generator system.

Class-Ill AC supply : Normally powered from Class-IV buses but can also be supplied from on-site standby sources (DG Sets). The loads connected to this power supply system shall be capable of tolerating power supply interruption of about three minutes.

Class-II AC Supply : This is the most reliable AC power supply source and provides uninterrupted power supply to the loads connected to the Class II buses, even when class- IV/class-III supplies fail, and strictly speaking, can be interrupted for a duration of a few milliseconds only. CONTRACTOR should limit the load connected to PURCHASER's Class-II system such that the total continuous demand shall not exceed 50kW and momentary load during starting of any connected motor to 175kVA at 415V AC, 3-phase. Necessary soft starters or drives should be considered if required.

Class-I DC Supply : This is the most reliable DC power supply source and it provides uninterrupted DC power supply to the loads connected to the Class I buses, even when class IV/class III supplies fail. This power supply shall only used for control, protection, logic relays, low power solenoids etc., and shall not be used for motors, motor operated valves etc.

Selection of the voltage vis-a-vis load and tolerances in voltage and frequency variation are covered in Section C-1-1.

9.0 Codes and Standards

9.1 All equipment and systems covered under this specifications shall comply with the latest editions as on date of Notice Inviting Tender (NIT)(including amendments thereto) of currently applicable codes, standards, statutes, regulations and safety codes in the locality where the equipment will be installed but not limited to the codes and standards listed herein as well as in various sections of this specification. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

9.2 In the event of any conflict between codes and standards referred to elsewhere in the specifications and the requirements of this specification, the more stringent of the two shall govern.

9.3 Other National Standards are acceptable if they are established to be equal or superior to the standards indicated herein as well as in various sections of this specification subject to approval by the PURCHASER. CONTRACTOR will be responsible for establishing the equality or superiority of other standards than those specified here. In all such cases, however, legal copies of English translation of such National Standards shall be furnished along with the tender. The tenders not complying with this requirement are liable for rejection.

9.4 The TENDERER shall submit his proposal both in MKS units and SI units. During detailed engineering, the CONTRACTOR shall use SI units with corresponding MKS units in parenthesis. The CONTRACTOR shall engrave MKS units on equipment rating plates & instruments.
Wherever word “latest” has been used it should be understood as applicable as on date of NIT.

9.5 Codes and Standards of following Institutes are applicable as specified in various sections of this specification :-

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

BUREAU OF INDIAN STANDARDS (BIS)

MANUFACTURERS STANDARDIZATION SOCIETY (MSS)

PIPING FABRICATORS INSTITUTE (PFI)

AMERICAN WELDING SOCIETY (AWS)

BRITISH STANDARDS INSTITUTE (BSI)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ANSI /IEEE

ANSI-NEMA

ANSI /ASME – PERFORMANCE TEST CODES

HEAT EXCHANGE INSTITUTE STANDARDS (HEI) / SPECIFICATIONS

INTERNATIONAL ORGANISATION FOR STANDERDISATION

NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION (NEMA)

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

AMERICAN SOCIETY FOR NON- DESTRUCTIVE TESTING (ASNT)

ISI STEAM TABLES

TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION (TEMA)

INSTRUMENT SOCIETY OF AMERICA (ISA)

FEDERAL OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATIVE STANDARD (OSHA)

ANSI/ISA S75.02 CONTROL VALVE CAPACITY TEST PROCEDURE

AMERICAN GEAR MANUFACTURER'S ASSOCIATION

HYDRAULIC INSTITUTE STANDARDS

ATOMIC ENERGY REGULATORY BOARD (AERB) SAFETY GUIDE FOR WORKS CONTRACT (NO. AERB / SG / IS-1).

ATOMIC ENERGY (FACTORIES) RULES. (Compliance to these rules is mandatory)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

In the event of conflicts between different standard codes, CONTRACTOR shall refer the conflict to PURCHASER for written resolution.

10.0 REQUIREMENTS

10.1 AVAILABILITY REQUIREMENTS

10.1.1 All plant and equipment included in this contract shall be designed for maximum reliability and availability. The bidder shall indicate the life of all the components that would require replacement and the replacement schedule. The bidder shall also indicate the inspection required and its schedule for all the components of the valve.

10.1.2 The plant should be capable for operating two years without need of any interruption on account of scheduled maintenance/replacement activity by design.

10.1.3 All equipment and systems shall be of proven design using materials with established physical and chemical properties adequately demonstrated in operation and as appropriate to the service intended.

10.2 LAY OUT REQUIREMENTS

10.2.1 The CONTRACTOR shall note that as per site layout the location of the turbine buildings GHAVP -1 and GHAVP -2 are mirror image.

CONTRACTOR shall also note that location of Isolated Phase Bus Duct (IPBD), Condenser Cooling water (CCW) tunnel, Pipe and Cable Bay of control building and Electrical Bay location are mirror image for GHAVP -1 and GHAVP -2. Contractor shall note from the site layout that location of pipe and cable bay in control building is also mirror image w.r.t turbine building longitudinal centre line.

Layout of TG & Auxiliaries, MSR and Condenser inside turbine building shall be identical for both the units.

The layout of other equipment, piping, ducting, cabling etc. inside turbine building shall be identical, to the extent practical.

Due to the mirror image layout of IPBD, CCW tunnel electrical bay and pipe and cable bay of control building, resulting changes in layouts of GHAVP unit-1 and unit-2 turbine buildings shall be engineered by the CONTRACTOR.

All drawings and documents to be furnished by CONTRACTOR to PURCHASER shall be separate for units 1 and 2, prepared unit-wise.

The layout shall be such as to provide adequate working space and operator access. Suitable ladders and platforms shall be provided to enable operators to reach the top of the equipment and near the major valves for operation and maintenance of equipment and valves. Adequate space for carrying out maintenance shall be provided around equipment. Adequate space shall be provided for rotor / cartridge withdrawal for rotating equipment, tube bundle / shell withdrawal space shall be provided for all heat

exchangers. Adequate lay down space shall be provided for various parts of equipment to be dismantled during maintenance, the floor in this lay down / withdrawal shall be capable of taking the load of dismantled parts, this is specifically so for heavy components. The floor over which equipment are required to be taken from the unloading bay to their places of installation and vice-versa shall be also designed considering the maximum weight of equipment required to be taken through the route. The area for lay down as well as the floor path for movement of equipment shall be marked on the floor with specific marking and information. Also, no equipment, cable trays, piping etc. should be located on this floor path.

ALL the control panels for the TG & auxiliary systems and secondary cycle systems shall be located in a room located on top of the workshop / chemical laboratory (in the TB annexe) at an elevation of 122m elevation.

Height of the room shall be at least 5.0 meters. The above room includes the requirements of PLC panels, relay panels, marshalling panels, network panels, PC workstation for C&I of secondary cycle system.

CONTRACTOR may note that the slope in PC bay is towards Turbine Building for flow of water in case of any Feed Water pipe line rupture in PC bay. Turbine Building design shall allow natural draining of this water through turbine building drains and various openings on floors. Connecting bridge between PC bay and Turbine Building shall have side wall to avoid any spillage of water to the road below.

CONTRACTOR shall note that in extended portion of PC bay which is in CONTRACTOR's scope instead of wall louvers shall be provided on both the side, for proper ventilation of the area.

It should be ensured that the $H_2/CO_2/N_2$ storage room for day to day requirement is provided such that it is isolated from the remaining building by means of concrete wall and should have an access from outside area. This room shall be preferably outside turbine building. CONTRACTOR shall note that H2/CO2/N_2 cylinder room location shall be on opposite side of transformer yard.

A workshop (common for both units-1&2) shall be provided in one turbine building (unit-1) annexe with adequate area in turbine building to accommodate the machines, tools crib, oil room, valve testing facility and welding shop etc. Details of machines to be accommodated in workshop have been given in Annexure-A to this section. Workshop area shall be estimated by the bidder based on the above details. Further detailing required for execution of work is in CONTRACTOR's scope.

Chemical laboratory (common for both units-1&2) for analysis of steam, water, lubricating oil etc. of the plant shall be provided in other turbine building (unit-2) annexe where workshop is not provided. Chemical laboratory shall be air conditioned. For chemical laboratory, area required is 30m x 20m and the same shall be air conditioned.

CONTRACTOR shall finalize the area required in turbine building considering all the systems, structure and components included in the scope and requirements of the workshop and chemical laboratory etc. Considering the requirement of locating chemical laboratory, workshop, and other facilities in turbine building, bidder may extend the building size. However, the size of the turbine building should be limited to the area marked for turbine building in drawing no. GHAVP-1,2/10000/5001/GA/R1.

Unloading bay location shall match with the location of rails, on which the GT will be brought to unloading bay, as shown in drawing no. GHAVP-1/51210/5001/GA/R0 & GHAVP-2/51210/5001/GA/R0 enclosed with this specification. For this purpose the unloading may be extended towards the road on the east side, to the maximum extent. Minimum clear space between the columns of unloading bay of turbine building shall be 13750 mm, considering the maintenance of Generator transformer in unloading bay.

All the pipes and cables etc. which are routed below ground, outside turbine building and leading to or coming out of basement, should not penetrate turbine building below ground. Pipes & cables shall be taken up and then enter the turbine building above ground.

Boiler feed pump shall be located on the ground floor. In order to meet the NPSH requirement de-aerator location shall be suitably worked out by CONTRACTOR. Condensate transfer pump shall also be located on the ground floor.

If any equipment (e.g. boiler feed pumps) requires acoustic enclosure then the foot print and area requirement for the same shall be considered in the layout.

10.3 DESIGN REQUIREMENTS

10.3.1 VALVES AND SPECIALITIES

a) Detailed data sheets and specifications of valves and specialties to be supplied by CONTRACTOR shall be furnished to PURCHASER.

b) All tests specified for the valves and specialties supplied under this contract shall be carried out on each and every single valve and specialty supplied.

c) Where regulating globe valves have been specified, the disc shall be suitable for controlling throughout its lift.

d) All actuators shall be suitable for outdoor location.

e) Diaphragm valves shall be suitable for vacuum service.

f) Unless otherwise noted, the time required for closing/opening of the motor operated valves shall be based on operating speed of 300 mm / min.

10.4 SEISMIC REQUIREMENT

10.4.1 Only seismic requirement for codal portion of system is, that the anchoring and supports of all equipment shall be designed for the seismic coefficient as per IS 1893 such that during the seismic activity the equipment shall not come out of it's foundation. Forces of both horizontal and vertical directions shall be considered for analysis and design.

For safety class II systems and equipment the floor response spectra will be given to successful bidders for Operating Basis Earthquake and Safe Shutdown Earthquake. All system and equipment specified as safety class II shall be designed as per ASME section III NC and supports shall be designed as per ASME section III NF and containment components as per ASME section III NE.

Reliability and availability values for all safety related equipment to be obtained by the CONTRACTOR from the respective equipment manufacturers and the same shall be submitted to PURCHASER for review and reference.

10.5 QUALITY ASSURANCE PROGRAMME

10.5.1 INTRODUCTION

Requirements of testing, inspection and quality Surveillance have been indicated in other sections and are also contained in various specifications. In addition to these requirements, the following clauses emphasize certain aspects of quality assurance, applicable to the whole of this contract in general.

a) The quality assurance programme shall provide control over all activities affecting the quality and reliability of all the equipment, components and services included in this contract. The programme shall include but not be limited to the activities of Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing, trial operation, performance testing and handing over. Activities affecting quality shall be accomplished under suitably controlled conditions namely, use of appropriate equipment, suitable environmental conditions, adequate cleanliness and other prerequisites for the particular activity. The programme shall take into account the need for special controls, processes, test equipment, tools and skills to attain the required quality, and the need for verification of quality by inspection and test.

b) CONTRACTOR shall furnish the quality assurance programme for review by PURCHASER which shall include but not be limited to the requirements of this specification. CONTRACTOR shall provide to PURCHASER all documents and records relating to quality programme and audit status for activities affecting quality.

c) Representative QAPs for major equipment / component of this package are

enclosed in respective sections. TENDERER shall furnish the QAPs covering all but not limited to the activities indicated in the enclosed QAPs along with the offer for all equipments and systems and activities. Upon placement of order PURCHASER will review and approve these QAPs which will form the basis for execution of contract.

10.5.2 DESIGN/ENGINEERING CONTROL

a) The CONTRACTOR shall establish measures to assure quality standards pertaining to various design documents such as Concept notes, design basis reports, design calculations, analysis reports, optimization studies, all drawings, design manuals, etc. and, deviations from such standards shall be controlled by the CONTRACTOR. Measures shall be established for the identification and control of design interfaces in respect of revision of documents, review, approval, release and distribution.

b) The design control measures shall provide for verifying or checking the adequacy of design, such as by the performance of design reviews, by the use of alternate or simplified calculation methods, or by the performance of a suitable testing program. Where a test program is used to verify the adequacy of a specific design feature in lieu of other verifying or checking processes, it shall include suitable qualification testing of a prototype unit under the most adverse design condition.

c) All computer software used by CONTRACTOR/SUB-CONTRACTOR in the design and engineering of his systems, equipment or components which have a bearing on their integrity or function shall be proven and adequately validated. Validation documents of all such software shall be submitted to PURCHASER for approval.

10.5.3 MATERIAL CONTROL

a) All materials shall be procured from the manufacturer and not from trader. All materials used for construction shall be of tested quality as per relevant codes/standards. Co-relating test certificates or details of results of the tests (in the absence of co-relating test certificates) conducted to determine the electrical properties, mechanical Properties, chemical analyses and details of heat treatment procedures etc. shall be furnished to the PURCHASER.

b) The CONTRACTOR shall be responsible for (1) establishing suitable measures to meet all the requirements of material specification (2) the quality during manufacture, including control of testing, examination, repairs, and treatment of the material, (3) surveying, qualifying and auditing the supplies of material.

c) For all materials used or supplied, co-relating test certificates or certified material test reports shall be provided for all operations performed by CONTRACTOR or his SUB-CONTRACTOR. This report shall certify that all

operations performed by CONTRACTOR or by his SUBCONTRACTOR are in compliance with the requirements of the applicable material specifications.

d) All materials used or supplied under this contract shall carry suitable identification marks such as heat marks or heat numbers and any additional marking required which shall enable identification of the source and origin of the material when required. These reference identification marks or numbers shall be mentioned in the accompanying material test certificates. Further, these marks or numbers shall remain distinguishable throughout the fabrication and erection process employed.

e) For bought Out Items (BOIs), if any, CONTRACTOR shall submit QA program for the same. Also, sub-vendors selected shall be with the approval of PURCHASER. CONTRACTOR shall submit the QAP for BOIs for PURCHASER's approval.

10.5.4 FABRICATION CONTROL

a) The Contractor shall ensure that all fabrication processes including welding & heat treatment are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria and other special requirements.

b) All materials shall carry identification markings, which will remain distinguishable until the component is assembled or installed. If the original identification marking are cut off or the material is divided, either the marks shall be transferred to the parts cut or a coded marking shall be used to ensure identification of each piece of material during subsequent fabrication. A tabulation of materials shall be made identifying each piece of material with the certified material test report and the coded marking.

c) The CONTRACTOR shall maintain a record of his qualified welding procedures and of the welders and welding operators qualified by him, showing the date and results of tests and the identification mark assigned to each welder. These records shall be reviewed, verified, and signed by an authorised Individual assigned by the CONTRACTOR, and they shall be accessible to the PURCHASER.

d) Post weld heat treatment (PWHT) shall be performed in Temperature - surveyed and - calibrated furnaces, or PWHT shall be performed with thermocouples in contact with the material or attached to blocks in contact with the material. Time-temperature recordings of all post-weld heat treatments shall be made available for review to the PURCHASER. Identification on the time-temperature recording shall be to the weld, part, or component.

10.5.5 INSPECTION AND TESTING

10.5.5.1 a) The Contractor shall establish and execute a program for inspection of activities affecting quality to verify conformance with the documented instructions, procedures and drawings. Examinations, measurements, or tests of materials or products shall be performed for each work operation to assure quality. In case of all mandatory inspection hold points, which require witnessing or inspecting by the PURCHASER's designated representative and beyond which work shall not proceed without the consent of the designated representative, the specific hold points shall be indicated in appropriate documents prior to Commencement of production activities in consultation with PURCHASER.

b) In order to assure that items will perform Satisfactorily in service, the CONTRACTOR shall establish written test procedures to incorporate the requirements and acceptance limits contained in applicable design documents. Test procedures shall include provisions for assuring that all prerequisites for the given test have been met, that adequate test instrumentation is available and used, and that the test is performed under suitable Environmental conditions. Test results shall be documented and evaluated to assure that test requirements have been satisfied.

c) Prior to the actual installation of SSCs, certain preliminary inspection and checks shall be performed to verify that the items conform to specified requirements. Checks shall be made to Verify that the identity of received materials and mechanical items have been maintained and are in accordance with the latest approved-for-construction drawings, specifications, and established procedures.

d) Inspections of the work in progress shall be performed to verify that the SSCs are being located, installed, assembled or connected in compliance with the latest approved-for-construction drawings and procedures. Following the installation of SSCs, the checking, inspection and testing activities shall be performed to verify that the completed items are in conformance with specified requirements.

10.5.6 PACKAGING AND TRANSPORT

a) The CONTRACTOR shall provide proper & adequate packaging of items for protection against corrosion, contamination, physical damage or any other effect that would otherwise lower the quality of items during the time they are transported, handled and stored. The packaging requirements of an item shall be based upon the important physical characteristics and the importance to safety and reliability of the item. The activities for packaging of items shall conform as appropriate, to the following criteria :

i) Items shall be inspected for cleanliness just before packaging.

ii) All openings into items shall be capped, plugged, and sealed. Weld ends shall be protected from corrosion and physical damage.

iii) Items subject to detrimental contamination on corrosion shall be suitably protected.

iv) Items packed in containers shall be blocked, Braced are cushioned to prevent damage.

v) The identity of the item shall be maintained by marking or any other appropriate means.

b) The mode of transportation shall be consistent with the protection requirements of the item and with the packaging methods employed. During loading and transit, adequate precautionary measures for protection against environmental conditions, fire, mechanical damage etc. shall be adopted. Package, preservative coatings, sealed openings etc. shall be visually inspected and damaged areas repaired prior to transport.

10.5.7 RECEIVING & STORAGE

a) The contents of all shipments the receipt of which is CONTRACTOR'S responsibility shall be visually Inspected by CONTRACTOR to verify that the specified requirements of identification and marking, protective covers & seals, coating & preservatives, inert gas blanket etc. as appropriate, have been maintained. Care shall be taken to avoid ingress and contamination by foreign materials during inspection.

b) Items on receipt shall be stored as appropriate for that level of item in order to avoid damage or lowering of quality due to corrosion, contamination, deterioration, or any other physical damage. The type of storage provided and measures taken to ensure that the material in store would be well preserved until erection shall be to PURCHASER's satisfaction and approval. Periodic inspections shall be performed by CONTRACTOR to assure that storage areas are being maintained in accordance with applicable requirements. For further details refer Section C-1-26.15.

10.5.8 ERECTION

a) Prior to actual erection of SSCs , the CONTRACTOR shall perform certain preliminary inspections, checks, and similar activities that shall be completed to verify that the SSCs and the erection area conform to specified requirements, and the necessary resources are available to assure that the quality of the SSCs will be maintained as the erection proceeds. Consistent with the schedule of construction activities, the CONTRACTOR shall verify that processes and procedures are ready for use in the erection of items.

b) The CONTRACTOR shall verify that conditions of the erection area conform to specified requirements and precautions have been taken to prevent conditions that will adversely affect the quality of the items during erection. The CONTRACTOR shall perform the activities in a systematic manner to assure surveillance throughout the erection process.

c) The CONTRACTOR shall establish a system of controls for work in progress to assure that the items have been located, installed, assembled or connected in compliance with the latest approved-for-construction drawings, instructions, and procedures. Checks shall be performed to verify that the items have been correctly erected and will function properly so that the initial starting of items and pre-operational testing can proceed with a minimum amount of problems and delays.

d) The CONTRACTOR shall establish a system of controls at site in order to assure compliance with the following.

i) Verification and certification of supplied equipment conforming to dimensional drawings before erection.

ii) Identification and certification of material grade and specifications of pipe spools / fittings prior to erection.

iii) Certification of piping fit-up before commencement of pressure welding.

iv) Verification of piping erection procedure to be evolved for each system before erection.

v) Clearance by Purchaser before final welds

10.5.9 SITE TESTING

a) Following the erection of mechanical items, the CONTRACTOR shall perform testing in accordance with specified requirements to assure that the strength and integrity of the erected system or portions there of conform to requirements. Various aspects such as the purpose of test, test boundary, duration of test, acceptance criteria, restoration etc. shall be established and documented. The CONTRACTOR shall furnish the details of procedures to PURCHASER for review and approval. Test data shall be evaluated and analysed for acceptance against acceptance criteria & operating limits. Test results with a report of data analysis and evaluation shall be furnished to the PURCHASER.

10.5.10 DOCUMENTATION CONTROL

a) The core of the quality assurance programme lies in the preparation and maintenance of documents which control the various quality assurance activities. All steps or activities instituted explicitly to assure quality shall be properly documented as per a pre-determined format which shall be subject to PURCHASER's review and approval. The documents shall include the objective(s) of the QA activity, Procedure followed, specification or code requirements, acceptance criteria, results of the measures taken and conclusions. The documents shall be compiled specific to the subject project and shall be duly signed by various authorised personnel of CONTRACTOR/SUB-CONTRACTOR. Where the activities are witnessed by PURCHASER or his authorised representative, the related documents would also be countersigned by the witness. Copies of these documents shall be made available to PURCHASER.

b) PURCHASER shall have the right to carry out quality audit and quality surveillance of the systems and procedures of the CONTRACTOR/SUB-CONTRACTOR. The CONTRACTOR shall provide all necessary assistance to enable the PURCHASER or his representative to carry out such audit and surveillance.

c) All drawings and documents pertaining to Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing, trial operation, performance testing and handing over shall be issued and controlled in a timely manner. The CONTRACTOR shall follow PURCHASER'S drawing/document numbering procedure while numbering drawings and documents. The CONTRACTOR shall submit all drawings and documents for PURCHASER's review. The CONTRACTOR shall ensure that the reviews have been performed by the PURCHASER.

d) Quality assurance documentation in respect of special processes such as welding, heat treatment, non-Destructive examination, etc. prepared by CONTRACTOR shall include radiographic films, records of UT, MP and DP tests, time-temperature charts, welders and procedure qualification reports, etc.

10.6 All electric motors to be used in turbine island shall be as per PURCHASER's following motor specifications.

HV Motors Specification No. PC-E-501
MV Motors Specification No. PC-E-502
MV Motors Specification No.PC-E-503

The requirement of thermal insulation for piping, equipment and ducting under the scope of this package shall be as per PURCHASER's specification PC-E-275

The requirement of welding of piping i.e., field welding shall be as per PURCHASER's specification of PC-P-285.

The technical specification for cleaning method for piping shall be as per PC-P-345

Technical specification for piping fabrication and erection of Nuclear Power Plants PC-P-344.

All above specifications are enclosed in Apendix-A of C-1.

10.7 QUALITY MANAGEMENT SYSTEM

Following should be read in conjunction with clause no 16 of GCC.

10.7.1 Inspection shall be the responsibility of the Contractor. Quality surveillance shall be done by NPCIL or its authorized representative at least at the stages identified in the approved QAPs

10.7.2 The Turbine Island package covers the systems and equipments required for supply of steam and feed water which demands highest degree of quality and reliability standards. In line with these requirements, the Contractor shall have documented quality management system to manage and assure the quality at all stages of engineering, procurement, manufacture, inspection, examination and testing, handling and shipment, pre-fabrication, erection and system testing.

10.7.3 The Contractor shall have a dedicated group of experienced and qualified inspection engineers and inspectors responsible for ensuring the implementation of quality management system and quality surveillance/quality control program at their work, their Sub-Vendors/ manufacturing works and fabrication, erection and testing work at site. The Contractor should have his own adequate no. of qualified Quality Surveillance/Quality control personnel to carry out the inspection activities at different stages as per the requirements or for monitoring performance of hired inspection personnel of approved agency at important locations in India and abroad.

10.7.4 All the personnel performing activities affecting quality of items shall have necessary qualifications, training and experience and duly authorized for specified processes and activities by Contractor and subsequently accepted by NPCIL before their deployment on job. Agency along with the personnel deployed by the Contractor shall be approved by NPCIL based on their competence on the desired activities.

All Non-destructive examinations (NDE) as required shall be performed by qualified personnel as per procedures approved by NPCIL. NDE shall be witnessed by Contractor's QS personnel / its authorized inspection personnel

who shall be minimum level-II certified from ISNT / ASNT. Contractor's NDT In-Charge shall have necessary Level-III certified in relevant methods for preparation / review of NDE procedures or job specific technique sheet. He shall have the responsibility of ensuring the implementation of applicable procedures / methods at site as per the requirements.

Senior management in the organization i.e. Package In charge at HQ / at site shall ultimately be responsible for the QMS programme and shall ensure it is established, implemented, assessed and continually improved.

QA In-Charge responsible for monitoring overall effectiveness of QMS programme shall be identified. He shall report to top management level sufficiently high to assure that considerations such as cost and schedule do not override QA requirement. He shall be a Graduate in Engineering with minimum 15 years experience in the field QA activities. Inspection engineers shall have sufficient experience and have minimum qualified with Diploma in Engineering in the relevant field. However their deployment on specific job shall be based on assessment by Contractor and acceptance by NPCIL by authorization process.

Contractor QA In-Charge shall monitor effectiveness of implementation of QMS programme and issue reports on monthly basis bringing out strength / area for improvement with a copy to NPCIL in a format agreeable to NPCIL.

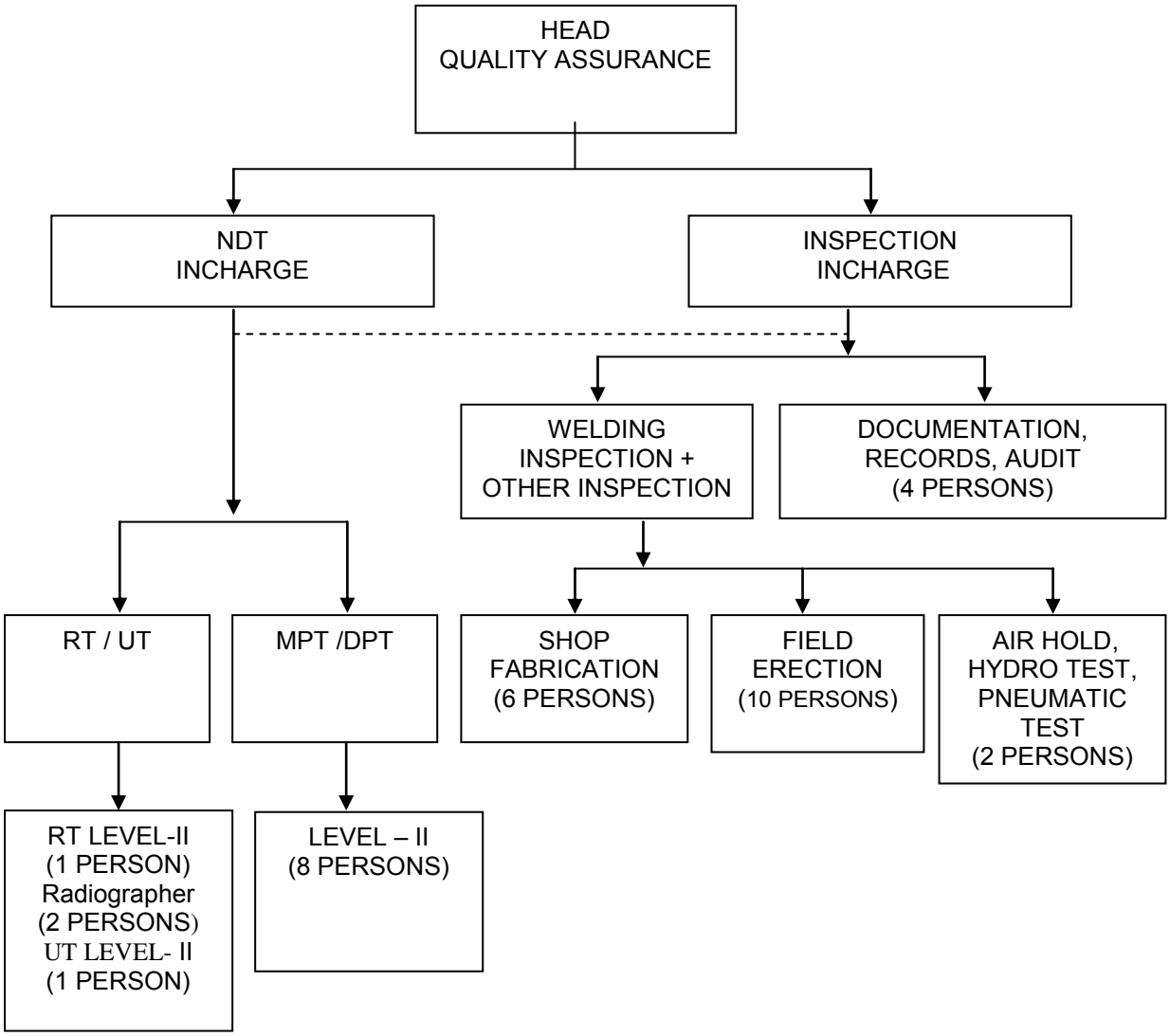
10.8 The proposed Quality Control and Inspection organization of the Contractor and general qualification requirements of QA personnel at site is given in enclosed Annexure-A

Though the qualification requirement of QA personnel is given, all persons of Contractor's QA group shall however be evaluated by QA group of Engineer for their suitability in respect of experience, general qualification, knowledge and capabilities for ensuring requisite quality in the job before accepting them.

ANNEXURE-A

PROPOSED QUALITY CONTROL AND INSPECTION ORGANIZATION

SET UP DURING ERECTION AT SITE



Note:
The above figures are indicative. Actual manpower strength shall be adequate to meet project requirements.

Qualification Requirements of Quality Assurance Personnel

S.No.	Designation	Minimum qualification requirement
3	Quality Assurance In charge	- Graduate in Engg preferably in Mech Engg, - 15 years experience in QA activities
4	NDT Incharge	- Graduate in Mech Engg- - 10 years experience - NDT Level III qualification in UT,PT,MT,RT,VT.
5	Inspection Inchage	- Graduate in Engg preferably in Mech Engg - 10 years experience in Inspection activities
6	NDT Inspectors	- Diploma in Engg / Science Graduate - NDT Level II qualification in respective NDT method - 5 years experience
7	NDT Operators	- ITI / 12^{th} Std. - NDT Level I qualification in respective NDT method - 3 years experience
8	Welding Inspector	- Diploma in Engg. (Mech or Metallurgy) - Qualification in welding inspector course. - 5 years field experience of weld inspection
9	Inspectors (for other inspection works)	- Personnel deployed for other Inspection activities for various disciplines like mechanical, electrical, C&I, civil etc. shall have sufficient qualification, experience and knowledge. (Other inspection works includes inspection related to activities like pipe materials cleaning i.e. Pickling, Passivation, Detergent wash, etc., Bending, Equipment Alignment, Flange alignment, Torqueing, Supports inspection , Valve testing, System testing, QA documentation etc.)

Following machines shall be considered for sizing the workshop in Turbine Building

Sl.No.	Name of the Machine	Quantity	Make
1.	Lathe machine	01 No.	L 50 X 5000 HMT make or equivalent
2.	Lathe machine	02 Nos.	Craft master HMT make or equivalent
3.	Lathe machine	02 Nos.	NH – 26 X 3000 HMT make or equivalent
4.	Radial drilling machine	01 No.	RM – 65 HMT make or equivalent
5.	Surface grinder	01 No.	SFW 2 HMT make or equivalent
6.	Universal milling machine	01 No.	FN 3 U HMT make or equivalent
7.	Shaping machine shop	01 No.	Batliboy or equivalent
8.	Tools & cutter grinder	01 No.	Batliboy make or equivalent
9.	Bench & pedestal grinder	01 No.	
10.	Power saw	01 No.	
11.	Pipe & stud threading machine	01 No.	
12.	Hydraulic press	01 No.	
13.	Pedestal drilling machine	01 No.	

The above machines are not in the scope of CONTRACTOR.

There should be workshop in-charge cabin & tools crib shall be adjacent to machine shop. Overhead material handling facility shall be provided in machine shop. Space for minimum six work benches should be provided along with material handling facility.

Space shall be provided to keep six work benches along with suitable overhead material handling facility for maintenance work.

TOOLS CRIB

Tools crib should have heavy duty racks & compactors.

OIL ROOM

Room should have fire doors across the room. There should not be any opening in the room. Room shall be illuminated by anti-spark bulb of lights. Spillage collection arrangement shall be provided as per requirements of ISO – 14001.

VALVE TESTING FACILITY

Workshop should have facility to carry out hydro & pneumatic test of all types & sizes of the valves.

Instrument air & De-mineralized water facility shall be provided.

Suitable material handling facility to carry out handling of heavy duty valves along with suitable working table.

WELDING SHOP

Room shall be well ventilated. Should have good exhaust facility. Accessories required are as follows:

1. At least 03 Nos. of 440 Volt, 3 Phase AC power point & 03 Nos. Single Phase 220 Volt AC power point.

2. Suitable overhead material handling facility above the room.

11.0 WELDING

11.1 All welding involved in the construction and fabrication of plant and items covered under the contract shall be carried out in accordance with applicable codes. Purchaser approved welding consumables shall be used.

11.2 Welding procedures and welder's qualifications shall be approved by the PURCHASER. Where applicable, welders shall be tested as detailed in codes specified and appropriate to the corresponding weld position using test pieces of appropriate parent metal to be used on the job. The PURCHASER shall have the right to have any welder re-tested at any time during the contract.

11.3 Radiography and other NDT for the equipment / items covered under this specification shall be as indicated in other Sections and as per the applicable code / standards Only PURCHASER approved chemicals for liquid penetrant examination shall be used. All NDT shall be carried out by qualified personnel of ISNT or ASNT.

All NDTs shall be carried out as per the PURCHASER's specification for NDT, listed below.

1	QAD-NDT-PROC-UT-1	PROCEDURE FOR UT PSI & ISI OF PIPING AND VESSEL WELDS
2	PP-P-2010	PROCEDURE FOR ULTRASONIC EXAMINATION OF BUTT & FILLET WELD JOINTS IN STRUCTURAL STEEL FABRICATION
3	PP-P-2009	PROCEDURE FOR ULTRASONIC EXAMINATION OF PRESSURE RETAINING WELDS OF PIPING & VESSEL BUTT-WELD JOINTS
4	PP-P-2013	PROCEDURE FOR ULTRASONIC EXAMINATION OF STEEL CASTINGS FOR GENERAL PURPOSE.
5	QAD-NDT-PROC-UT-06	PROCEDURE FOR ULTRASONIC EXAMINATION OF STEEL FORGINGS FOR GENERAL PURPOSE
6	PP-P-2011	PROCEDURE FOR ULTRASONIC EXAMINATION OF STEEL PLATES BY MANUAL CONTACTMETHOD
7	PP-P-2012	ULTRASONIC EXAMINATION PROCEDURE FOR SHAFT MATERIAL
8	PP-P-2016	PROCEDURE FOR PSI AND ISI UT THICKNESS GAUGING -PIPING COMPONENTS - SURVEY OF EROSION -CORROSION
9	QAD-NDT-PROC-UT-11	GENERAL REQUIREMENTS OF ULTRASONIC EXAMINATION
10	QAD-NDT-PROC-MT-01	PROCEDURE FOR MPT WITH PROD TECHNIQUE
11	QAD-NDT-PROC-MT-02	ROCEDURE FOR MPT WITH YOKE TECHNIQUE
12	QAD-NDT-PROC-MT-03	PROCEDURE FOR MPT WITH WET HORIZONTAL / STATIONARY MPT MACHINE FOR GEARS, DISC AND FLANGE
13	QAD-NDT-PROC-MT-04	PROCEDURE FOR MPT WITH WET HORIZONTAL / STATIONARY MPT MACHINE FOR HOLLOW (ID&OD) PARTS.

14	QAD-NDT-PROC-MT-05	PROCEDURE FOR MAGNETIC PARTICLE TESTING WITH HORIZONTAL/STATIONERY MAGNETIC PARTICLE MACHINE
15	QAD-NDT-PROC-PT-01	PROCEDURE FOR LIQUID PENETRANT EXAMINATION (COLOUR CONTRAST SOLVENT REMOVABLE TYPE)
16	QAD-NDT-PROC-PT-02	PROCEDURE FOR LIQUID PENETRANT EXAMINATION (COLOUR CONTRAST WATER WASHABLE TYPE)
17	QAD-NDT-PROC-PT-03	PROCEDURE FOR LIQUID PENETRANT EXAMINATION (FLUORESCENT)
18	QAD-NDT-PROC-PT-04	PROCEDURE FOR LIQUID PENETRANT EXAMINATION (GENERAL REQUIREMENT)
19	QAD-NDT-PROC-PT-05	PROCEDURE FOR APPROVAL OF FAMILY OF CHEMICALS USED FOR LIQUID PENETRANT EXAMINATION
20	QAD-NDT-PROC-ET-01	PROCEDURE FOR EDDY CURRENT EXAMINATION OF HEAT EXCHANGER TUBES
21	QAD-NDT-PROC-ET-03	PROCEDURE FOR EDDY CURRENT TESTING OF TUBES
22	QAD-NDT-PROC-RT-01	PROCEDURE FOR RADIOGRAPHIC EXAMINATION OF WELDS.
23	PP-P-00001	Visual Testing and Measurement Inspection of SCC's during PSI and ISI

Copies of these specifications are enclosed in Appendix-A of Section C-1.

12.0 INSPECTION AND TESTING

12.1 The inspection and testing for design & engineering, procurement, various equipment and accessories and erection and commissioning shall be as detailed in other Sections of this Tender.

12.1.1 The Design & Engineering, Manufacture of equipment accessories Procurement, Erection / Construction, commissioning & testing, performance testing, trial operation and handing over, covered by this Contract shall be subjected to inspection and testing. The CONTRACTOR shall provide all services to establish and maintain quality of workmanship in his works and that of his SUB-CONTRACTORS and to site to ensure the mechanical / electrical performance of systems and components, compliance with drawings, identification and acceptability of all materials, parts and equipment.

12.1.2 On award of the Contract, the CONTRACTOR shall prepare Quality Control Plan identifying the various stages of Design & Engineering, Manufacture of equipment accessories Procurement, Erection / Construction, commissioning & testing ,performance testing, trial operation and handing over, quality checks performed at each stage and the PURCHASER hold points. The document shall also contain details of method of checking, inspection and acceptance standards / values and get the approval of PURCHASER or his representative before proceeding with Design & Engineering, Manufacture of equipment accessories Procurement, Erection / Construction, commissioning & testing, trial operation and handing over. However PURCHASER or his representative shall have the right to review the inspection reports, quality checks and results of CONTRACTOR'S in-house inspection department which are not PURCHASER hold points and the CONTRACTOR shall comply with the remarks made by PURCHASER / representative on such reviews with regards to further testing, rectification or rejection etc.

12.1.3 The CONTRACTOR shall perform his internal inspection/ testing before offering the same for PURCHASER'S inspection. Only after ensuring that his inspection/test results are satisfactory, CONTRACTOR shall offer for PURCHASER's inspection. However, this clause is not applicable in case of such test which are required to be done only once in the life time of the equipment.

The minimum inspection requirements for Design & Engineering, Manufacture of equipment accessories Procurement, Erection / Construction, commissioning & testing, performance testing, trial operation and handing over shall conform to the requirements as defined in the Codes and Standards, specifications referred to in the specification document. The type of inspection shall be as prescribed in Quality Control Plan and as agreed upon by the PURCHASER, and shall include, if applicable, inspection procedures prescribed by Codes and Regulations recognised by the Governmental Authority having jurisdiction over the installed goods.

12.1.5 Wherever required, getting approval of Government bodies under jurisdiction is the sole responsibility of the CONTRACTOR for his Design & Engineering, Manufacture of equipment accessories Procurement, Erection / Construction, commissioning & testing, trial operation and handing over by such bodies. In such cases approval by Government bodies under jurisdiction will not relieve the CONTRACTOR from his responsibility of making good of defective system, structure and component. However, CONTRACTOR shall keep the PURCHASER/his representatives informed in writing of any approval or otherwise any comments of such Government bodies. CONTRACTOR shall take the concurrence of PURCHASER or his representative before proceeding with rectification procedures as called by the Government bodies.

12.1.6 Approval or passing of any such inspection by the PURCHASER or his authorised representative shall not, however, prejudice the right of the PURCHASER to reject the equipment if it does not comply with the Specification when erected or give complete satisfaction in service.

12.1.7 The CONTRACTOR shall intimate to the PURCHASER of any system, structure, component being ready for testing. Such tests shall be to the CONTRACTOR'S account except for the PURCHASER'S expenses. The PURCHASER or his representative, unless the inspection of the tests is virtually waived, shall attend such tests within a reasonable period of the date on which the equipment is notified as being ready for test/inspection, failing which, the CONTRACTOR may proceed with the tests which shall be deemed to have been made in the PURCHASER'S presence and CONTRACTOR shall forward the duly certified copies of tests along with observation readings to the PURCHASER.

12.1.8 The PURCHASER shall give notice in writing to the CONTRACTOR of any objection to any drawings/document and, all or any equipment, system, structure and workmanship which in his opinion is not in accordance with the 'Contract'. The CONTRACTOR shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the PURCHASER giving reasons therein that no modifications are necessary to comply with the 'Contract'. However, PURCHASER has the final authority to accept or reject the CONTRACTOR'S views. The system, structure & component after rectification by the CONTRACTOR shall be offered to the PURCHASER for his final inspection and acceptance without any additional cost to PURCHASER.

12.1.9 When the tests have been completed at the CONTRACTOR'S or his SUB-CONTRACTOR'S Works, at site, to the satisfaction of the PURCHASER, the PURCHASER shall issue a certificate to this effect within fifteen (15) days after completion of tests, but if the tests are not witnessed by the PURCHASER'S representative, the certificate shall be issued within fifteen (15) days of the receipt of the CONTRACTOR'S test certificate by the PURCHASER provided the tests results are satisfactory and conform to the specified parameters. Failure of the PURCHASER

to issue such a certificate shall not prevent the CONTRACTOR from proceeding with the subsequent Work. The completion of these tests or the issue of the certificate shall not bind the PURCHASER to accept the equipment should it, on further tests after erection, commissioning & trial operation be found not to comply with the 'Contract'.

12.1.9 In all cases where the 'Contract' provides for tests whether at the premises or Works of the CONTRACTOR or of any SUB-CONTRACTOR, or at site, the CONTRACTOR, except where otherwise specified shall provide free of charge such items as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the PURCHASER or his authorised representative to carry out effectively, such tests of the equipment in accordance with the 'Contract' and shall give facilities to the PURCHASER or to his authorised representative to accomplish testing.

12.1.10 The inspection by the PURCHASER and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the CONTRACTOR in respect of the agreed quality assurance programme forming a part of the 'Contract'.

12.1.10 CONTRACTOR shall proceed from one stage to another only after the inspection by the PURCHASER or his representative and permission given to proceed further. The same procedure shall be adopted for any rectifications/repairs suggested by the PURCHASER or his representative. At all PURCHASER hold points, the CONTRACTOR shall compulsorily offer for inspection to PURCHASER and, if any waiver by PURCHASER, shall be obtained in writing for record purposes.

12.1.11 None of the system, structure & component to be furnished or used in connection with the Contract shall be dispatched until shop inspection, satisfactory to the PURCHASER or his representative has been made and specific Despatch Instruction for the equipment is issued by the PURCHASER. However, such shop inspection shall not relieve the CONTRACTOR of his responsibility for furnishing plant conforming to the requirements of the Contract nor prejudice any claim, right or privilege which the PURCHASER or his representative may have because of the use of defective or unsatisfactory items of the system, structure & component. Should the PURCHASER or his representative waive the right to inspect any item of the system, structure & component, such waiver shall not relieve the CONTRACTOR in any way from his obligation under the Contract. In the event of the PURCHASER on inspection revealing poor quality of goods, the PURCHASER or his representative shall be at liberty to specify additional inspection procedures, if required, to ascertain the CONTRACTOR'S compliance with the specifications.

12.1.12 Test reports as called for in this specification shall be supplied for all tests carried out including other records such as stress relieving charts, radiographic charts and other non-destructive testing records in accordance with the provisions of the Contract. The PURCHASER or his representative shall reserve the right to call for certificates of

origin and test certificates for all raw material and equipment at any stage of manufacture.

12.2 SUB-ORDERS

12.2.1 CONTRACTOR shall get the approval of PURCHASER by furnishing details of capability, experience, manpower of SUB- CONTRACTOR for Design & Engineering, Manufacture of equipment accessories Procurement, Erection / Construction, commissioning & testing ,performance testing, trial operation, quality control facilities, etc. before placement of order. To ensure getting good quality product from SUB- CONTRACTOR, the CONTRACTOR shall evaluate the details of capability experience, manpower of SUB- CONTRACTOR for Design & Engineering, Manufacture of equipment accessories Procurement, Erection / Construction, commissioning & testing ,performance testing, trial operation, quality control facilities, etc. After completion of evaluation all details shall be furbished to purchaser for his evaluation and approval. The sub-orders should highlight the inspection and quality control requirements stipulated in the main Specification and all required quality checks and tests shall be conducted as per the specification.

12.2.2 In order to facilitate the inspection of bought-out services, materials and plant, the CONTRACTOR shall submit for approval, three (3) copies of all sub-orders placed by CONTRACTOR as soon as they are issued. Copies of any drawings referred to in the sub-order shall also be submitted, unless otherwise agreed by the PURCHASER or his representative.

12.2.3 All sub-orders shall clearly be marked with the main CONTRACTOR'S name and PURCHASER's reference. They shall include a statement advising the SUB-CONTRACTOR that items being ordered will also be subject to inspection and test by the PURCHASER or his representative.

12.2.4 It is important that all copies of sub-orders be clearly marked with the main CONTRACTOR'S name and the name of the PURCHASER and Contract' reference.

12.2.5 The SUB-CONTRACTORS are to comply with all the applicable requirements of this Specification and in particular with this section. Orders issued by the SUB-CONTRACTOR are also to include the main CONTRACTOR'S name on their sub-order in addition to the above mentioned heading.

12.3 MATERIAL TESTS

12.3.1 CONTRACTOR shall ensure that all the inspection and testing of the equipment manufactured by his sub-vendor will be witnessed by the CONTRACTOR’s representative.

12.3.2 In case the correlating test certificates are not available the CONTRACTOR, at no extra cost to the PURCHASER will get all the tests done to establish conformity of the material to its relevant code / specification.

12.4 TESTS AT MANUFACTURER'S WORKS

12.4.1 General

The tests at Works shall include all tests in accordance with the appropriate clauses of Statutory Regulation, relevant Codes and Standards and in addition any test called for by the PURCHASER or his representative to ensure that the equipment being supplied fulfils the requirements of the Specification. The CONTRACTOR shall carry out all the shop tests and inspections specified under individual items of equipment in this specification, in addition to those normally carried out by him. For equipment not covered by any code or specifically mentioned in this Specification, the tests are to be agreed with the PURCHASER. If considered necessary by the PURCHASER or his representative, multi-part assemblies shall be fully erected and tested in the Works prior to packing and dispatch to the Site.

12.4.2 Test Certificates

Test certificates including test records, performance curves and balancing certificates shall be supplied. All the tests shall be carried out in accordance with the provisions of this 'Contract'.

12.5 TEST & INSPECTION REPORTS

The following documents shall be supplied:

12.5.1 Test certificates for all materials employed in the manufacture of the equipment. These certificates shall furnish the results of all the tests required to be carried out in accordance with the material standards, statutory codes and supplementary requirements of these specifications and shall include chemical analysis, mechanical and metallurgical tests, visual examination, dimensional checks, non-destructive and destructive tests, proof tests, leak tests, performance test, type tests etc.

12.5.2 Certified copies of raw material inspection and test reports as issued by the equipment suppliers works.

12.5.3 Reports on weld procedure and welder qualification tests conducted at works.

12.5.4 Heat treatment records.

12.5.5 Visual and dimensional checks.

12.5.6 All non-destructive examination reports including photographs taken along with films.

12.5.7 Reports of all tests conducted on semi-finished and finished items and tests during all erection activities which shall include but not be limited to the following:

a) Mock-up tests
b) Hydrostatic tests or any other proof tests
c) Pneumatic tests or any other leakage tests
d) Tests on all electrical equipment
e) Performance Tests carried out at works
f) All functional tests carried out in the works
g) All type tests carried out in the works

12.5.8 Holiday detection tests, if any.

12.5.9 All test certificates as required by statutory authorities and regulations.

12.5.10 Cleaning records.

12.5.11 Any other inspection or test report as may be required by PURCHASER.

All the above records shall be also be submitted after completion of work as history docket.

13.0 QUALITY SURVEILLANCE

13.1 The TENDERER shall submit a detailed Quality Assurance Manual at the time of submitting their technical bid to ensure that all the activities and service under the scope of this tender, whether manufactured or performed within his Office /Works or at his SUB-CONTRACTOR'S Office /works or at PURCHASER'S Site or at any other place of work are in accordance with the specified requirements.

The Quality Assurance Manual shall cover the aspects as indicated in various sections of this specification and shall be in line with the quality assurance manual of purchaser.

The quality assurance programme of the contractor shall be in consonance with the quality assurance programme of PURCHASER.

Therefore contractor’s quality system shall as a minimum address the following:

a) Organisation structure and interfaces between various agencies / sub vendors / subcontractors.
b) Functions and responsibilities of the contractor/ sub vendors / subcontractors.
c) Requirements on qualification and training of personnel in each area of activity viz. Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over.
d) Control of design.
e) Control of procurement and manufacturing.
f) Control of Quality.
g) Control of Erection / Construction.
h) Control of commissioning & testing.
i) Calibration and control of measuring, examination and test equipment.
j) Manufacturing environment, equipment and special process control.
k) Handling shipping and storage control.
l) Non-conformance control in each area of activity viz. Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing, trial operation, performance testing and handing over.
m) Corrective actions in each area of activity viz. Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over.
n) Quality assurance records.
o) Document control, their storage and retrieval in each area of activity viz. Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over.
p) Internal audits.

This QA programme shall be subject to acceptance by PURCHASER and changes as necessary to bring it in line with PURCHASER, QA programme shall be made by the CONTRACTOR.

Quality Assurance Plans (QAPs) for manufacture of major equipment covered under this package are enclosed. These QAPS indicates PURCHASER's technical requirements, however detailed QAPs all the equipment incorporating all requirements shall be prepared and furnished by CONTRACTOR for PURCHASER's approval. CONTRACTOR shall note that Inspection and testing requirements for all equipment are to be governed by national/international codes/standards/guides/general industrial practices. QAPs for erection, commissioning and testing activities involved shall be prepared by CONTRACTOR and submitted to PURCHASER for approval. CONTRACTOR shall prepare detailed quality assurance plans based on QAPs enclosed and submit them for approval of PURCHASER before starting manufacture, supply, erection, commissioning and testing. Equipments and activities of erection, commissioning and testing activities for which QAPs are not enclosed the CONTRACTOR shall prepare the QAPs and submit the same to PURCHASER for approval.

PURCHASER, will carryout the regular audits (once in six months) of contractor in all phases of the work. i.e. Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over.

13.2 The PURCHASER and/or his duly authorised representative shall have at all reasonable times access to the CONTRACTOR's premises or Works and shall have the power, at all reasonable times to inspect and examine the activities, materials and workmanship during Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over and if part of the activity, equipment is being carried out / manufactured or assembled on other premises or Works, the CONTRACTOR shall obtain for the PURCHASER and/or his duly authorized representative, necessary permission to inspect as if the activities, equipment were carried out / manufactured or assembled on the CONTRACTOR's own premises or Works.

13.3 The PURCHASER or his representative shall have the right to inspect any design & engineering office, machinery, material, structures, equipment or workmanship during Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over activities furnished or used by the CONTRACTOR and may reject any which is defective or unsuitable for purpose intended, or which is not in accordance with the intent of the contract. The CONTRACTOR, upon demand by the PURCHASER or his representative,

shall remedy or replace at the CONTRACTOR's expense such defective or unsuitable activity / items of the plant, or the PURCHASER may, at the expense of the CONTRACTOR, remedy or replace such defective or unsuitable activity /items of the plant.

13.4 The PURCHASER or his representative shall at all working hours have access to all parts of the CONTRACTOR'S and his SUB-CONTRACTOR'S works where the items of the plant are being designed, engineered, manufactured & fabricated and shall be provided with all reasonable inspection facilities by the CONTRACTOR. The inspection facilities shall include all necessary tools, instruments, equipment and qualified operators to facilitate inspection. This includes access necessary to verify the implementation of all aspects of QA program. A set of latest prints of the relevant approved drawings/documents shall be made available by the CONTRACTOR to the PURCHASER or his representative for reference during inspection.

13.5 For the purpose of this clause, inter-works orders are be treated as sub-orders. It is obligatory on the CONTRACTOR that he advises his SUB-CONTRACTOR of the pertinent clauses in this specification when ordering bought-out design, plant, equipment or materials. In particular, the CONTRACTOR is to advise each SUB-CONTRACTOR that he is required to supply design calculations, drawings, inspection reports and test certificates strictly in accordance with this specification and technical information for inclusion in the documents to be submitted for the PURCHASER.

13.6 The CONTRACTOR is to provide test pieces as required by the PURCHASER's representative to enable him to determine the quality of material supplied under this contract. If any test piece fails to comply with the requirements, the PURCHASER's representative may reject the whole material represented by the test piece. The PURCHASER or his representative shall have the right to select particular test piece of his choice from the lot in case of sample testing. In case the results are found to be not satisfactory the PURCHASER's representative shall have the right to test more number of pieces/each piece additionally from the lot for testing or reject the whole lot.

13.7 Quality surveillance by Purchaser or his authorised representative includes, but is not limited to verification, witness & hold points. These points would be finalised on approval of detailed quality assurance plan submitted by CONTRACTOR. Additional witness and hold points can be established by PURCHASER if manufacturing or related activities or inspection, test results warrants so.

13.8 Witness points are critical steps in Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over where the contractor is obliged to notify in sufficient advance of the start of activity/operation /inspection/ test so that it may be witnessed by PURCHASER QS. Contractor will intimate in advance their Design & Engineering, Manufacture,

Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over schedule to PURCHASER for planning the coverage of witness point.

The contractor may proceed with the work past a witness point if the PURCHASER's QS is not available at the appointed time.

Hold points are critical steps in Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over where the contractor is obliged to notify PURCHASER's QS in sufficient advance of the start of activity/operation /inspection/ test so that it shall be witnessed by PURCHASER's QS. Final release prior to shipment is a mandatory Hold Point. The contractor is not to proceed with the work past a Hold Point except by written waiver / agreement by PURCHASER.

The performance (or waiver) of quality surveillance activities by PURCHASER's QS or its authorised representative at any stage of manufacturing, installation, erection, commissioning and testing, does not relieve the contractor of any obligations to perform in accordance with and meet all requirements of the procurement documents and also all the codes / referencing documents mentioned in the procurement document nor shall it preclude subsequent rejection by PURCHASER's QS. Quality surveillance activities carried out by PURCHASER is only to ensure that the approved quality program prepared by CONTRACTOR himself is followed.

On completion of manufacture, the items can be despatched only after issue of shipping release by a quality surveyor of PURCHASER.

13.9 The CONTRACTOR shall be responsible for the erection, commissioning, testing, performance testing work in order to hand over the equipment / systems to the PURCHASER in the correctly erected conditions. A comprehensive erection, commissioning, testing, performance testing quality assurance programme necessary for structure, system and equipment shall be prepared by CONTRACTOR and these documents shall include, but not be limited to; a) erection, commissioning, testing, performance testing procedure, b) drawings for erection and c) quality checks during erection, commissioning, testing. These documents shall be submitted to the PURCHASER for review and approval and indicating witness / hold points.

13.10 The CONTRACTOR shall be responsible for checking the quality of the erection, commissioning, testing at each stage of work, controlling the erection, commissioning, testing quality as well as progress.

13.11 Erection, commissioning, testing work shall be proceeded with according to the erection, commissioning, testing control documents and the results shall be approved by the

PURCHASER. When any problem is found, the erection, commissioning, testing work shall be stopped and solution to the problem shall be found in consultation with PURCHASER.

13.12 The CONTRACTOR shall deploy necessary personnel, tools & tackles and infrastructure at site to the satisfaction of PURCHASER for carrying out all erection, testing, inspection and quality surveillance activities who shall check the performance of erected equipment / systems and confirm that the erection quality meets the requirements of the PURCHASER's specification, regulations, etc.

13.13 The CONTRACTOR shall be responsible for the Design engineering and procurement work in order to hand over the equipment / systems to the PURCHASER in the correctly operating conditions. A comprehensive design, engineering and procurement quality assurance programme necessary for design, engineering and procurement of turbine island shall be prepared by CONTRACTOR and these documents shall include, but not be limited to; a) design, engineering and procurement procedure, b) quality checks. These documents shall be submitted to the PURCHASER for review and approval and indicating witness / hold points.

13.14 In the event of any non-conformance of any system, structure and component at any stage, the CONTRACTOR shall submit the Non-Conformance Report (NCR) duly reviewed and approved by their designer. The CONTRACTOR shall proceed further only after the PURCHASER's concurrence on the NCR.

14.1 GUARANTEES

The CONTRACTOR shall guarantee that the Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over of the system, structure and equipment meet the requirements of these specifications.

The word goods used here means Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing, trial operation, performance testing and handing over of the system, structure and equipment as covered in the scope of this specification.

With respect to the goods covered in the specifications the CONTRACTOR shall provide to the PURCHASER, guarantees:

14.2 Of Title

The CONTRACTOR warrants that the goods are not subject to any security interest, lien or other encumbrance.

14.3 Against Patent Infringements

Except when the PURCHASER furnishes design specifications to the CONTRACTOR, the CONTRACTOR shall at his own expense, defend and save the PURCHASER harmless from the expenses and consequences of any suit or procedure brought against the PURCHASER, so far as said suit or procedure is based on a claim that the goods furnished constitute an infringement of any patent in existence on the date of the order. In addition, the CONTRACTOR shall secure at his own expense a fully paid up license or licenses that will permit the PURCHASER to continue use of the goods furnished free of further claim for infringement.

14.4 Of Quality

a) The period of defect liability for the turbine island package shall be 12 months from the date of acceptance of performance test of full power operation for 72 hours or 18 months from the date of construction completion and complete commissioning of all the system/subsystems of turbine island package except those require nuclear steam for commissioning, whichever is earlier, for each unit.

b) The guarantee period shall be extended by the length of time required to make any adjustments, changes or repairs necessary to fulfill the guarantees.

c) The CONTRACTOR shall obtain similar guarantees from each one of his SUB-CONTRACTORS. However, the overall responsibility shall be with the CONTRACTOR.

14.5 Of Performance

The CONTRACTOR shall guarantee that the goods furnished by him are in full accordance with the requirements of the enquiry specifications including codes and standards referred herein.

14.6 Guarantee required for each individual system, structure and equipment are given in individual section in section C-2.

15.1 The basic consideration and the essence of the contract shall be strict adherence to the time schedule for performing the specified works.

15.2 CONTRACTOR shall note that turbine island for each 700 MWe unit, i.e. GHAVP-1 and GHAVP-2 should be erected in parallel in order to meet the time schedule as agreed with the PURCHASER. Accordingly, CONTRACTOR shall deploy adequate manpower, material, machines and facilities to meet the targeted dates for completion of work.

15.3 The time periods shown below are for Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing, trial operation, performance testing and handing over of Turbine Island for GHAVP-1 and GHAVP-2 as follows:

15.4 For first unit (GHAVP-1), Completion of Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing, of all system, structure and components including barring gear operation of turbine generator of Turbine Island shall be within 54 months from the date of placement of purchase order. Further activities such as trial operation, performance testing and handing over shall be carried out after the nuclear steam is made available, within 3 months from the date TG set is put on barring gear operation i.e within 57 months from the date of placement of purchase order.

For second unit (GHAVP-2), the above periods are extended by a period of 6 (six) months.

The major milestones for the execution of work from the placement of PO are as given below:

(a) Milestones for GHAVP-1:

(i) Completion and handing over of PCB of TB, Electrical bay and Transformer yard : 33 months from the placement of order.
(ii) Completion of TG foundation and turbine building: 38 months from the Placement of Order.
(iii) Commissioning and handing over of class 2 portion of main steam system, main feed water system up to grid F of control building from SGs and complete auxiliary feed water and SGBD systems (complete in all respects including hydro test & mass and alkaline flushing): 48 months from the placement of Order.
(iv) Commissioning and handing over of complete secondary cycle systems : 51 months from the placement of Order.
(v) Putting TG set on barring (shaft turning gear) gear: 54 months from Placement of Order.
(vi) Full power operation and handing over of the systems: 57 months from the placement of order.

(b) Milestones for GHAVP-2:

(i) Completion and handing over of of PCB of TB, Electrical bay and Transformer yard : 39 months from the placement of order.
(ii) Completion of TG foundation and turbine building: 44 months from the Placement of Order.
(iii) Commissioning and handing over of class 2 portion of main steam system, main feed water system up to grid F of control building from SGs and complete auxiliary feed water and SGBD systems (complete in all respects including hydro test & mass and alkaline flushing): 54 months from the placement of Order.
(iv) Commissioning and handing over of complete secondary cycle systems: 57 months from the placement of Order.
(v) Putting TG set on barring (shaft turning gear) gear: 60 months from Placement of Order.
(vi) Full power operation and handing over of the systems: 63 months from the placement of order.

Bidder should confirm that the schedule of activities for TI package will meet the above major milestones.

15.5 The CONTRACTOR shall be responsible for performance of his works in accordance with the specified time period. If at anytime, the CONTRACTOR is falling behind the schedule, he shall take necessary action to make good such delays by accelerating the progress of the work or by increasing his work force or by working overtime or otherwise to comply with the schedule and shall communicate such action in writing to the PURCHASER satisfying that his action will compensate for the delay. The CONTRACTOR shall not be allowed any extra compensation for such action. In such situations, the PURCHASER shall, however, not be responsible for provision of additional manpower, materials or machines or supply or any other services to the CONTRACTOR.

15.6 Duration of completion of turbine island package is as indicated above, CONTRACTOR shall note that complete feed water system up to steam generator including boiler feed pumps, de-aerator, condensate extraction pumps, condensate transfer pumps, auxiliary boiler feed pumps, auxiliary condensate storage tanks, condensate storage tanks including piping fittings , main steam lines from steam generators including ASDVs, MSSVs, MSIVs including control and instrumentation of these systems shall be ready in 51 months for GHAVP-1 and 57 months for GHAVP-2 so that feed water can be supplied to steam generator and heat from steam generators can be removed through ASDVs for hot conditioning of primary heat transport system. CONTRACTOR shall specifically confirm this in his offer.

15.7 Civil works of electrical bay of turbine building shall be progressively released for installation of electrical equipment and associated cable tray works etc. therefore

electrical bay & transformer yard need to be made ready well in advance so that power supply to all systems is available as per schedule.

16.1 **GENERAL**

16.1.1 Tenders shall be deemed to be under consideration immediately after they are opened and until such time official intimation of award/rejection is made by the PURCHASER to the TENDERERS. While the tenders are under consideration, TENDERERs and/or their representatives or other interested parties are advised to refrain from contacting by any means, the PURCHASER and/or his employees/representatives on matters related to the tenders under consideration. The PURCHASER if necessary will obtain clarification on the tenders by requesting for such information from any or all the TENDERERS, either in writing or through personal contact as may be necessary. TENDERER will not be permitted to change the substance of the tender after the tender has been opened.

16.1.2 TENDERER's offer shall be complete covering entire scope. However PURCHASER reserves the right to split a package and award it to more than one TENDERER if it proves advantageous to him.

16.1.3 This specification lays down the minimum technical requirements, which shall be complied with. If the TENDERER wishes to offer a design or material different from the one specified but equal or superior to it, he may do so by submitting an alternate offer. However a base tender shall be submitted based on particular requirements as specified. It is TENDERER's responsibility to demonstrate the equivalence or superiority of his alternate offer to the specifications contained herein. No extra credit would be given to any claim of superiority during tender evaluation. PURCHASER reserves the right to reject or accept all such alternate offers. All alternate offers, which are inferior to the tender specifications, are liable to be rejected.

16.1.4 It is necessary that TENDERERS indicate their prices in format enclosed in section-E of this specification. Failure to furnish prices in a comprehensive manner as called for in section E of the specification will render the offer liable for rejection.

TENDERER / CONTRACTOR shall submit the UNPRICED copy of section –E, which he will be submitting as part II of this tender. All items which are filled by TENDERER / CONTRACTOR shall be indicated by "*" in this UNPRICED copy of section-E.

16.2 TENDER EVALUATION

PURCHASER will evaluate the TENDERs based on lump sum price quoted by the TENDERERs for the complete scope of work as specified.

The evaluation of the tender will be based on the net output offered by the tenderer. The net output is the difference between the TG output at the Generator terminals with condenser vacuum at 0.1Kg/cm^2 (a) and the power consumption by the auxiliary equipment covered in this tender. With the datum as the maximum net output offered, the prices of the other bidders will be loaded proportional to the respective

differences between the maximum net output and the net output offered by a particular bidder. The loading will be (Max net output offered (MWe) - net output offered (MWe) by the respective other bidders) x 50 crores.

Contractor shall note based on the performance test of the plant, any decrease in the net output with respect to the guaranteed value offered by the contractor will attract a penalty at the rate of Rs. 840000000/-(Eighty four Crores) per Mega-Watt. Contractor shall also note that any increased output, however, will not attract any bonus.

The guaranteed output at the generated terminals shall be indicated in the schedule of guarantee. Bidder shall note that all the equipment which would be in operation on continuous basis shall be included for computing the auxiliary power consumption. The list of all these equipment also shall be indicated in schedule of guarantees, without indicating the power consumption values.

All tests including performance tests at site shall be conducted as described in various Sections in this specification.

18.0 TRIAL OPERATION AND HANDING OVER

18.1 STARTUP AND COMMISSIONING

Upon satisfactory completion of erection, the CONTRACTOR shall initiate pre-commissioning checks, inspections, tests, adjustments and trial runs required to put the complete plant under the scope into satisfactory, reliable and unrestricted commercial use.

18.2 Startup shall include:

a) Thorough inspection of all equipment and ancillaries that are erected to ensure that they can be started, availability of power supply at the equipment, checking of lubricant for all moving equipment, availability of cooling water through respective heat exchangers wherever necessary.

b) Checking direction of rotation of motor drives for moving equipment before coupling.

c) Internal cavities of equipment to be free of any debris or any combustible material that might present an explosion hazard.

d) Availability of instrumentation for safe operation of equipment and auxiliaries.

e) Trial run and no-load run of all equipment.

f) Test all interlock and instrumentation.

TRIAL OPERATION

18.3 After plant is ready for commercial use, it would be on trial operation during which period all necessary adjustments shall be made while operating in the full load range enabling the plant to be made ready for performance tests.

18.4 The duration of Trial Operation of the complete plant as in the scope shall be spread over a period at different load regimes out of which it would be continuously operated at full load for at least seventy two (72) hours or any other duration as may be agreed to, between the PURCHASER and the CONTRACTOR. The Trial Operation shall be considered successful, provided that each item of the plant can operate continuously at the specified operating condition, satisfactorily for the period of trial operation.

18.5 A trial operation report comprising observations and recordings of various parameters to be measured in respect of the above trial operation shall be prepared. This report, besides recording the details of various observations during trial run, shall also include the time and dates of start and finish of the trial operation and shall be signed by the representatives of both the parties. The report shall include recording of all details of interruptions that occurred, adjustments made and any minor repairs done during the trial operation. Based on the observations, necessary modifications/repairs to the plant shall be carried out by the CONTRACTOR to the full satisfaction of the PURCHASER to enable the latter to accord permission to carry out performance tests on the plant.

PERFORMANCE TEST

18.6 Upon successful completion of the trial operation the performance test of the complete plant under the scope shall be conducted as specified in this specification. The date of commencement of performance tests shall be within a month of completion of trial operation or as may be mutually agreed upon.

18.7 These tests shall be binding on both the parties of the Contract to determine compliance of the equipment with the performance guarantees.

18.8 The CONTRACTOR shall submit a detailed write-up on performance test procedures for all the systems, structures and equipment covered under the scope, along with sample calculations for PURCHASER's approval and the same shall be finalised prior to actual performance testing.

18.9 The tests will be conducted at the specified load points and as near the specified conditions as practicable.

18.10 All test instrumentation for the performance and efficiency tests as required, shall be supplied by the CONTRACTOR and shall be retained by him upon satisfactory conclusion of all such tests at the site. All costs associated with the supply, calibration, installation and return of the test instrumentation shall be included in the contract price. The test instrumentation for the performance test shall be of precision type with accuracy limits in accordance with the performance test codes. Instruments for performance tests shall be used subject to calibration check at site, before as well as after the performance test. Calibration shall be done by the CONTRACTOR at his cost and shall be witnessed by PURCHASER. Calibration records prepared by CONTRCATOR and witnessed by PURCHASER shall be included in the performance test report.

18.11 Any special equipment, tools and tackles required for the successful completion of the performance tests shall be provided by the CONTRACTOR, free of cost.

18.12 The guaranteed performance figures of the systems, structures & equipment shall be proved by the CONTRACTOR during these performance tests. Should the results of these tests show any decrease from the guaranteed values, the CONTRACTOR shall modify the equipment as required to enable it to meet the guarantees. In such a case, performance tests shall be repeated within twenty one (21) days from the date the equipment is ready for re-test and all cost for modifications including labour, mechanical overhauling / repair and the cost of additional testing to prove that the equipment meets the guarantees shall be borne by the CONTRACTOR.

HANDING OVER

18.13 On successful completion of the performance testing, the PURCHASER will take over the plant and equipment under guarantee through formal documentation consisting of a HANDING OVER CERTIFICATE jointly signed by the CONTRACTOR and the PURCHASER. The HANDING OVER CERTIFICATE shall include list of any defects, outstanding works to be completed by the CONTRACTOR. CONTRACTOR must commit a definite date by which he will complete all such outstanding works required for the satisfactory completion of entire scope. Any defects detected subsequent to signing of HANDING OVER CERTIFICATE shall be rectified by CONTRACTOR under GUARANTEE. The GUARANTEE period shall start from the date of HANDING OVER.

18.14 The HANDING OVER CERTIFICATE shall not be unreasonably withheld on account of minor omissions or defects, which do not affect the commercial service without any risk to the plant, provided always that the CONTRACTOR undertakes to make good such omissions and defects before mutually agreed dates. Such CERTIFICATES however shall be deemed to be on account and shall in no way release the CONTRACTOR from his liabilities and responsibilities in respect of such plant.

Before handing over the plant CONTRACTOR shall submit all the documents as called for in this specification to the entire satisfaction of purchaser.

OPERATIONAL GUARANTEE

18.15 The operation and maintenance of the complete plant during the guarantee period, as stipulated in the specification after take over under guarantee, will be carried out by the PURCHASER'S operation and maintenance staff in accordance with the CONTRACTOR'S operation and maintenance instruction manuals. The CONTRACTOR shall be responsible for remedying design, material, fabrication, and also responsible, for construction defects. During this period, the CONTRACTOR shall provide, if required by the PURCHASER, the services of operation engineers to advise the PURCHASER, for such periods and in such number as may be mutually agreed upon. The CONTRACTOR'S operation engineers shall also train the PURCHASER'S personnel, act as a liaison between the PURCHASER and the CONTRACTOR, assist the

PURCHASER in ordering and obtaining spare parts generally monitoring operation and maintenance and trouble shooting and supervising repair work under guarantee. On successful completion of the guarantee period, the complete plant will be taken over completely by the PURCHASER but with such conditions as may be mutually agreed to between the PURCHASER and CONTRACTOR depending upon the performance of the plant and equipment during the guarantee period.

19.0 SPARES

19.1 The TENDERER shall include in his scope of supply, all the necessary (i) Start-up spares (ii) Essential spares and (iii) Recommended spares, as described below. PURCHASER has listed the essential spares for all major equipment along with the technical requirements of equipment, for all other equipment CONTRACTOR shall finalise the requirement and indicate along with the bid. The PURCHASER reserves the right to finalise the exact quantities of the spare parts and effect price adjustment on the basis of the unit rates quoted by the TENDERER. The spares, ordered by the PURCHASER, shall be delivered at site along with the main equipment/plant. The requirement of spares shall be for a period of five (5) years for satisfactory operation of equipment / plant / system.

19.1.1 START-UP SPARES are those spares which may be required during start-up and commissioning of the equipment / plant / system. All spares used until the equipment/plant/ system is finally handed over by the CONTRACTOR to the PURCHASER shall come under this category.

19.1.2 ESSENTIAL SPARES are those spares which are considered necessary by the PURCHASER for five (5) years of normal plant operation. The term “ESSENTIAL” and “MANDATORY” may be considered as same. Consolidated list of mandatory spares for all items is enclosed in Annexure to this section.

The TENDERER shall quote unit rates for each of the Essential Spares. The total price of all Essential Spares, as listed in the tender document, shall be considered for tender evaluation. The PURCHASER reserves the right to alter the items and/or quantities of spares while placing the order.

19.1.3 RECOMMENDED SPARES are those spares which the 'TENDERER' considers necessary for five (5) years of normal plant operation, and which are not included in Essential Spares specified by the PURCHASER. The TENDERER shall indicate his recommended list of spares. Their unit prices shall also be indicated. The PURCHASER reserves the right to buy any or all of the Recommended Spare Parts. The total price of Recommended Spares shall not be considered while evaluating the tender.

19.2 The TENDERER shall also indicate the service expectancy period for the spare parts under normal operating conditions before replacement will be necessary. All spare parts shall be dispatched along with the main equipment concerned.

19.3 The TENDERER shall indicate the prices for each and every item specified in the tender document in the respective "Schedule of Spare Parts" whether or not he considers it necessary for the PURCHASER to have such spares. If the TENDERER fails to comply with the above or fails to quote the price of any spare item in the "Schedule of Spare parts", his bid may be considered incomplete and likely to be rejected. However, in case any specified spare part is not applicable for the equipment offered by the TENDERER, the same shall be indicated as 'Not Applicable'.

19.4 All spares supplied under this Contract shall be strictly interchangeable with the parts for which they are intended to be replacements. The spares shall be treated and packed for long storage under the climatic conditions prevailing at the Site, e.g. small items shall be packed in sealed transparent plastic bags with desiccant or as necessary.

19.5 Each spare shall be clearly marked or labeled on the outside of its packing with its description and purpose. When more than one spare part is packed in a single case, a general description of the contents shall be shown on the outside of such a case and the detailed list enclosed. All cases, containers and other packages must be suitably marked and numbered for the purposes of identification. A spare parts list with identification tag nos. for each spare part shall be furnished by CONTRACTOR for PURCHASER'S use.

19.6 All cases, containers or other packages are liable to be opened for such examination as the PURCHASER may reasonably require.

19.7 The CONTRACTOR shall guarantee the PURCHASER that before going out of production of spare parts, for the Equipment furnished, he shall give at least 12 months advance notice to the PURCHASER, so that the latter may order his requirement of spares in one lot, if he so desires.

19.8 MANDATORY spares listed in the annexure to this chapter are to be considered by bidder for bidding purpose. MANDATORY spares listed elsewhere (in other sections and specifications enclosed with this Turbine Island Specification) need not be considered for bidding.

ANNEXURE

LIST OF MANDATORY SPARES FOR TURBINE ISLAND PACKAGE OF 700 MWe GHAVP-1, 2

(MECHANICAL, ELECTRICAL AND C&I ITEMS)

Note-The quantities indicated are for two units unless otherwise specified. One set means requirement of one equipment. Wherever % is indicated it shall be rounded off to next higher value to get the number of spares to be supplied.

LIST OF MANDATORY SPARES FOR TURBINE AND AUXS. FOR 700 MWe OF GHAVP-1, 2 (COMMON FOR BOTH GHAVP 1 AND GHAVP 2 UNITS)

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
A		**TURBINE AND ITS AUXILIARIES :**			
1		Turbine casing studs, bolts, nuts and washers for inlet flange and turbine horizontal joint for internal and external casings.	Set	1	
2		**Bearings for Turbine**			
	2.1	Journal bearings	Set	1	One No. of the part containing the babbit material/ bearing of each bearing
	2.2	Thrust bearing pads	Set	1	
3		**Shaft glands and gland sealing**			
	3.1	Labyrinth sealing ring with integrated segment for HP module (front and rear)	Set	1	
	3.2	Labyrinth sealing ring with integrated segment for LP module (front and rear)	Set	1	
	3.3	Gasket for gland steam	Set	1	

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
		regulators			
4		**Lube Oil system**			
	4.1	Glasses for oil sight flow indicator (if applicable)	Set	1	
	4.2	Gaskets for Auxiliary & Emergency oil pump.	Set	1	
	4.3	Pressure regulator valve spring	No.	1	
	4.4	'O' rings for main oil pump.	Set	1	
	4.5	Gasket for oil coolers	Set	1	
	4.6	Body gasket	Set	1	
	4.7	Complete Main Oil Pump	Set	1	
	4.8	Auxiliary oil pump impeller	Set	1	
	4.9	Shaft sleeve for main oil pump	Set	1	
	4.10	Duplex Filter elements & cover gasket	Set	1	One set of each type
	4.11	Main oil tank filter	Set	1	
	4.12	Jacking oil pump motor	No.	1	
	4.13	Flexible connections for jacking oil system	Set	1	
	4.14	Wearing rings of auxiliary & emergency pumps	Set	1	One set of each type
5		**Control Valves**			
	5.1	Stem and seat	No.	See rem.	Two for each type
	5.2	Packing set	Set	See rem.	Two for each size
	5.3	O' Ring/Gasket	Set	See rem.	Two for each size
	5.4	Gaskets	Set	See rem.	Two each size
	5.5	Limit switches	No.	See rem.	One for each rating
	5.6	Positioner (including position transmitters)	No.	See rem.	Two of each type
6		Power Fuses for TGC	No.	See rem.	Six set of breaker (1 of each type), fuses and terminals
7		FCB Fuses for TGC	No.	See rem.	Five hundred of each size and rating
8		**Main Steam Emergency Stop Valve (ESV)**			
	8.1	Studs, bolts, nuts and washers for ESV cover	Set	1	
	8.2	Main Spring for ESV servo motor	Set	1	
	8.3	Other springs, if required for	Set	1	

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
		ESV			
	8.4	Valve stem bushes	Set	1	
	8.5	Valve plug	Set	1	
	8.6	Valve seat	Set	1	
	8.7	Gaskets for ESV cover	Set	2	
	8.8	Piston rings for ESV Servo mechanism	Set	2	
	8.9	Solenoid for emergency valve trip gear	No.	1	
	8.1	Oil seals for ESV	Set	2	
	8.11	Limit switches	No.	2	For each rating
9		**HP. Governing Valves**			
	9.1	Studs, bolts, nuts and washers for governing valve.	Set	1	
	9.2	Governing valve internal assembly as Stem & plug assembled; seat; Spare for mobile set (guide bushing, sleeves); Bush in 2 parts for coupling between servomotor stem & valve stem	Set	1	
	9.3	Main spring for governing valve	Set	1	
	9.4	Bushing for governing valve	Set	1	
10		**Interceptor Valves (IV) if provided**			
	10.1	Gaskets for interceptor valve cover	Set	2	
	10.2	Oil seals for interceptor valve	Set	2	
	10.3	Valve disc.	No.	1	
	10.4	Valve seat	No.	1	
	10.5	Limit switches	No.	See rem.	One for each rating
	10.6	Actuators	Set	1	
11		**Interceptor Stop Valves (ISV) if provided**			
	11.1	Studs, bolts, nuts and washers for ISV	Set	1	
	11.2	Main Spring for ISV servo motor	Set	1	
	11.3	Other spring, if required for ISV	Set	1	
	11.4	Valve stem bushes	Set	1	
	11.5	Valve disc	No.	1	

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	11.6	Valve seat	No.	1	
	11.7	Piston rings for ISV servomotor	Set	1	
	11.8	Actuator	Set	1	
12		Strainer Elements			
	12.1	For main steam emergency stop valves.	Set	1	
	12.2	For interceptor stop valves (if provided)	Set	1	
	12.3	Gaskets	Set	See rem.	Two sets of each type
B		**LIST OF MANDATORY SPARES FOR GENRATOR**			
1		**Generator**			
	1.1	Generator bearings	Set	1	
	1.2	Generator terminal bushings complete with hardware.	No.	6	
	1.3	Rotor cooling fan	Set	1	
	1.4	Rotor retaining ring	Set	1	One retaining ring of each side (2 nos.)
	1.5	Rotor damper wedges	No.	See rem.	10% of total quantity used
	1.6	Rotor long wedges	No.	See rem.	10% of total quantity used
	1.7	Stator bar	No.	See rem.	10% of each type (Subject to minimum 2 nos. of each type
	1.8	Rotor bar	No.	See rem.	10% of each type (Subject to minimum 2 nos. of each type
	1.9	Seal rings	Set	1	One set (1 No. for turbine end & 1 No. for exciter end
2		**Excitation System**			
	2.1	Field breaker	No.	1	
	2.2	Isolator	No.	See rem.	One of each type
	2.3	Card, Module, Indicating lamps, Meters and other hardware components	No.	See rem.	One (1) set consisting minimum Two (2) of each type
	2.4	Communication cable, pre-fabricated ribbon cables	No.	See rem.	One (1) set consisting minimum Two (2) of each type
	2.5	Fuses for devices	No.	See rem.	Five (5) of each type (I on
	2.6	Auxiliary PT, CTs, Shunts and field suppression resistor.	No.	See rem.	Set consisting of one of each Type

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	2.7	Power Electronic devices like Diodes. Thyristor etc.	No.	See rem.	One (1) Set consisting of 10% of components of each type subject to minimum 2 nos. of each type.
	2.8	Control MCBs	No.	See rem.	One (1) set consisting minimum Two (2) of each type
	2.9	Carbon brushes (Static Excitation System)	No.	See rem.	100% of the quantity provided in a brush gear assembly.
	2.10	Rotating diodes and fuses (Brushless excitation system)	No.	See rem.	50% of the quantity provided
	2.11	Carbon Brushes for rotor earth fault (Brushless excitation system)	No.	10	
	2.12	Slip Rings	No.	1	
	2.13	MMI device for communicating with AVR PLC	No.	1	
C		**LIST OF MANDATORY SPARES FOR CONDENSER**			
1		**Condenser air evacuation units**:			
	1.1	Gaskets and seals.	Set	1	
	1.2	Bearings	Set	1	
	1.3	Shaft and impeller.	Set	1	
	1.4	Heat exchanger gaskets.	Set	1	
	1.5	Air flow meter	No.	1	
	1.6	Rubber belt of the dog bone expansion joint or 10% of total springs used (as the case may be).	No	See rem.	One rubber belt or 10% of total springs
	1.7	Spare level gauges.	Set	1	
	1.8	Condenser tube plugs	No	See rem.	5% of total tubes.
D		**MANDATORY SPARES FOR SECONDARY CYCLE PUMPS**			
1		**Condensate Extraction Pump:**			
		Specified Quantities are total requirement of all pumps for one 700 MWe Unit. (One Set means total requirement of one pump) Considering 3 X 50% Pumps per unit			
	1.1	Shaft with keys etc.	Set	2	
	1.2	Impeller (one suction impeller & one stage impeller)	Set	2	

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	1.3	Shaft sleeves	Set	4	
	1.4	Thrust bearing	Set	2	
	1.5	Coupling with bolts set and bushes	Set	2	
	1.6	Line shaft bearing assembly	Set	6	
	1.7	Gland packing assembly	Set	2	
	1.8	Suction strainer element	Nos.	6	
	1.9	Wearing ring	Set	4	
2		**Heater drain pump**			
	2.1	Shaft, keys, etc.	Set	2	
	2.2	Impeller	Set	2	
	2.3	Shaft sleeves	Set	4	
	2.4	Wearing rings	Set	4	
	2.5	Thrust bearing	set	2	
	2.6	Suction strainer elements	set	4	
3		**Moisture Separator Drain Pump**			
	3.1	Complete rotor assembly including shaft and impeller	set	2	
	3.2	Mechanical seal assembly	set	4	
	3.3	Shaft, keys, circlips etc.	set	2	
	3.4	Shaft sleeves	set	4	
	3.5	Wearing rings	set	4	
	3.6	Bearings	set	4	
	3.7	Gaskets and 'O' rings	set	4	
	3.8	Suction strainer elements	set	4	
4		**SG Blowdown Booster pump**			
	4.1	Shaft	set	2	
	4.2	Impeller	nos.	2	
	4.3	Shaft sleeves	set	4	
	4.4	Suction strainer elements	set	4	
5		**Condensate Transfer pump**			
	5.1	Shaft	set	2	
	5.2	Impeller	nos.	2	
	5.3	Shaft sleeves	set	4	
	5.4	Suction strainer elements	set	4	
6		**BOILER FEED PUMPS**			

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	6.1	Complete cartridge (inner element) for main BFP comprises of shaft, impellers, suction annulus, complete shaft sealing and bearings	nos.	2	
	6.2	Bearings liners	set	8	
	6.3	Mechanical seal assembly	set	6	
	6.4	Impeller wearing ring with necessary screws	set	8	
	6.5	Low load recirculation control valve	nos.	2	
	6.6	Spare tubes for seal water coolers together with expanders	nos.	See rem.	100% of tubes for one cooler x 2
	6.7	Shaft	nos.	4	
	6.8	O-Rings and other gaskets	set	8	
	6.9	Shaft sleeves	set	6	
	6.10	Shaft sleeve nuts	set	2	
	6.11	Spare parts for shaft couplings	set	2	
	6.12	Spares for instruments	nos.	See rem.	Minimum Four nos. of field instruments for each type & each range or 20% of each type and each range whichever is higher
7		**BOOSTER PUMP OF BOILER FEED PUMPS**			
	7.1	Bearings	set	4	
	7.2	Complete rotor assembly including shaft and impeller	set	2	
	7.3	Impeller wearing ring with necessary screws	set	2	
	7.4	Mechanical seal assembly	set	4	
	7.5	Spare parts for shaft couplings	set	4	
	7.6	Gaskets and packings	set	4	
	7.7	O-Rings	set	4	
	7.8	Shaft sleeves	set	4	
	7.9	Spares for instruments	nos.	See rem.	Minimum 4 nos. of field instruments for each type & each range or 20% of each type and each range whichever is higher
8		**GEAR BOX OF BOILER FEED PUMPS**			

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	8.1	Bearing liners or bearing assemblies as applicable for all bearings	set	4	
	8.2	Oil filter elements for each type	set	2	
	8.3	Oil cooler tubes			
	8.4	For lube oil cooler	nos.	2	
	8.5	For working oil cooler	nos.	2	
	8.6	Gaskets	set	4	
	8.7	Shaft driven lube oil pump	nos.	2	
	8.8	AC motor driven auxiliary oil pump with motor	nos.	2	
9		**AUXILIARY BOILER FEED PUMPS**			
	9.1	Suction Impeller	nos.	4	
	9.2	Shaft Sleeves	set	4	
	9.3	Radial Bearings	set	4	
	9.4	Thrust Bearings	set	4	
	9.5	Mechanical seals	set	4	
	9.6	Shaft with keys and circlips	set	4	
	9.7	Wearing rings	set	4	
	9.8	Minimum flow cum non-return valve	nos.	4	
	9.9	Gaskets and ‘O’ rings	set	4	
E		**PIPING, VALVES, PIPING SPECIALITIES, HX & TANKS FOR TURBINE CYCLE (SECONDARY CYCLE SYSTEM)**			
1		**MAIN STEAM ISOLATION VALVES**			
	1.1	Bonnet cover gaskets	set	4	one set means requirement of one valve
	1.2	Gland packings	set	8	one set means requirement of one valve
2		**MAIN STEAM SAFETY VALVES**			
	2.1	Safety Relief valves (complete assembly)	nos.	3	
3		**DEAERATOR AND FEED STORAGE TANK**			
	3.1	Trays in Deaerator	nos.	See rem.	5% or minimum 2 nos. whichever is higher
	3.2	Spray nozzle in Deaerator	nos.	See rem.	10% or minimum 5 nos. whichever is higher
	3.3	Safety relief valves	nos.	See rem.	One for each type / size / rating

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	3.4	Adjusting spring for safety valve	nos.	See rem.	One for each type / size / rating
4		**CLOSED FEED WATER HEATERS, SGBD COOLERS AND DRAIN COOLERS**			
	4.1	**Safety relief valves-**			
	4.1.1	For Tube side	nos.	See rem.	One for each feed water heater
	4.1.2	For Shell side	nos.	See rem.	One for each feed water heater
	4.2	Adjusting spring for safety valve	nos.	See rem.	One for each type / size / rating for feed water heater /SGBD coolers / Drain coolers
	4.3	Gaskets	set	See rem.	One set for each type of heaters / SGBD coolers / Drain coolers
5		**TANKS**			
	5.1	Safety relief valves	nos.	See rem.	One for each tank
	5.2	Gaskets	set	See rem.	One set per tank
6		**Pipes, Gaskets & Pipe fittings**			
	6.1	Pipes	mtr.	See rem.	5% of total straight length for each size and material grade of pipe < 50 NB
	6.2	Gasket	nos.	See rem.	100% Total requirement of Gaskets
	6.3	Pipe Fittings (Size 65 NB to 200 NB)	nos.	See rem.	2% of each size / schedule/ material grade rounded to the next no.
7		**GATE,GLOBE, CHECK, DIAPHRAGM VALVES**			
	7.1	Valves (Gate / Globe/Check) (Size 50 NB and below)	nos.	See rem.	5% for each size / type / rating
	7.2	Bonnet/ Cover Gaskets	set	See rem.	1 each for every set of 10 identical valves or part thereof for each size /type/ rating
	7.3	Gland Packing	set	See rem.	1 set for every set of 10 identical valves for each size / type / rating
	7.4	Lapping Tool	set	See rem.	1 set for each size / type of valve
	7.5	O Ring	set	See rem.	1 each for every set of 4 identical valves or part thereof for each size /type/ rating

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	7.6	Valve stems for sizes 65mm	nos.	See rem.	1 per set of 10 valves or part thereof for each size / type / rating
	7.7	Disc or disc set as applicable for Gate & Globe valves and disc with hinge pin for check valve	set	See rem.	1 per set of 10 valves or part thereof for each size / type / rating
	7.8	Body seat ring for gage, globe and check valve	set	See rem.	1 per set of 25 valves or part thereof for each size / type / rating
	7.9	Yoke bushing for gage and globe valves	nos.	See rem.	1 per set of 25 valves or part thereof
	7.10	Diaphragms	nos.	See rem.	1 per set of 4 valves or part thereof
	7.11	Contactors	nos.	See rem.	1 each for every set of 10 identical valves or part thereof for each size /type
	7.12	Actuators	nos.	See rem.	1 each for every set of 10 identical valves or part thereof for each size /type
8		**BUTTERFLY VALVES**			
	8.1	Disc seal rings	set	See rem.	1 set for each size & rating
	8.2	Body set ring (replaceable type i.e. not integral with valve body)	set	See rem.	1 set for each size and rating
	8.3	'O' ring seals or gland packing	set	See rem.	1 set for each size & rating
9		**SAFETY AND RELIEF VALVES MOUNTED ON PIPING SYSTEM**			
	9.1	Bonnet Gasket	nos.	See rem.	One no. for each size/ type / rating of valve
	9.2	Disc & stem assembly	set	See rem.	One set for every size / type / rating of valve
10		**STRAINERS OTHER THAN PUMP SUCTION STRAINER**			
	10.1	Strainer screen/basket	nos.	See rem.	One no. for each strainer
	10.2	Cover Gaskets	nos.	See rem.	One no. for each strainer
11		**STEAM TRAPS**			
	11.1	Strainer element	nos.	See rem.	1 no. for each type & rating
	11.2	Gaskets	set	See rem.	1 set for each trap
12		**RECIPROCATING PUMPS: HYDRAZINE/ MONOETHANOL AMINE (MEA) DOSING PUMP**			
	12.1	Plunger	nos.	1	
	12.2	Valves	nos.	2	
	12.3	Relief Valves	nos.	1	

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	12.4	Bearings	set	See rem.	One set in each type
	12.5	'O' rings	set	See rem.	Two sets in each type
13		**GENERAL CONTROL VALVES**			
	13.1	Renewable seat rings	nos.	See rem.	1 per set of 10 valves or part thereof for each size / type / rating
	13.2	Gland packings	set	See rem.	1 set per valve for 4 identical valves or part thereof for each size / type / rating
14		**SPECIAL CONTROL VALVES**			
	14.1	Small Feed Control Valves	nos.	2	
	14.2	Large feed control valves	nos.	2	
	14.3	ASDVs	nos.	2	
	14.4	CSDVs	nos.	See rem.	20% of total no. of valves rounded to the next higher whole no. for two units
	14.5	Pegging steam control valves	nos.	See rem.	20% of total no. of valves rounded to the next higher whole no. for two units
	14.6	BFP Re-circulation valves	nos.	See rem.	2 nos. of valves for two units
	14.7	CSDVs		See rem.	Removable seat rings and gland packing should be provided as required for 10% of the total number of valves
	14.8	ASDVs	nos & set	See rem.	4 Nos. for removable seat rings + 4 sets of gland packing
	14.9	Pegging Steam Valves	set	See rem.	Removable seat rings and gland packing should be provided as required for 10% of the total number of valves.
	14.10	BFP Re-circulation Valves	nos & set	See rem.	2 Nos. of removable seat rings + 2 sets of gland packing
	14.11	Small Feed Control Valves	nos & set	See rem.	2 Nos. of removable seat rings + 2 sets of gland packing
	14.12	Large Feed Control Valves	nos & set	See rem.	2 Nos. of removable seat rings + 2 sets of gland packing
F		**EOT & UNDERSLUNG CRANE**			
1		Linings for Brakes			

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
2		Main Hoist & Auxiliary Hoist	No. (Pairs)	3	
3		Cross travel	No. (Pairs)	3	
4		Long Travel	No. (Pairs)	3	
5		**Bearings**			
	5.1	For each motor for all motions	Set	1	
	5.2	Main Hoist Gearbox & Auxiliary Hoist	Set	1	
	5.3	Cross Travel Gearbox	Set	1	
	5.4	Long Travel Gearbox	Set	1	
	5.5	Cross Travel Wheels	Set	1	
	5.6	Long Travel Wheels	Set	1	
6		**Oil Seals**			
	6.1	Gear Couplings	Set	2	
	6.2	Main Hoist gear box & Auxiliary Hoist	Set	2	
	6.3	Cross travel gear box	Set	2	
	6.4	Long travel gear box	Set	2	
7		**Brake Spring**			
	7.1	Main Hoist & Auxiliary Hoist	No. (Pairs)	1	
	7.2	Cross travel Unit	No. (Pairs)	1	
	7.3	Long Travel Unit	No. (Pairs)	1	
8		**Brake Disc**			
	8.1	Main Hoist & Auxiliary Hoist	No. (Pairs)	1	
	8.2	Cross travel Unit	No. (Pairs)	1	
	8.3	Long Travel Unit	No. (Pairs)	1	
9		**'O' Ring**			
	9.1	Main Hoist & Auxiliary Hoist	Set	2	
	9.2	Cross travel Unit	Set	2	
	9.3	Long Travel Unit	Set	2	

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
10		**Bearing Seal**			
	10.1	Main Hoist & Auxiliary Hoist	Set	2	
	10.2	Cross travel Unit	Set	2	
	10.3	Long Travel Unit	Set	2	
11		**ELECTRICAL**			
	11.1	Power and Control PCB Cards	Set	See rem.	1 Set for each Drive
	11.2	Push Button		See rem.	10 % of total qty.
12		Current collector of DSL		See rem.	One per each size.
G	**LIGHT WATER SYSTEM**				
		PUMPS,HEAT EXCHANGERS, VALVES, EXPANSION JOINTS etc.			
1		**PUMPS**			
	1.1	Impeller	No.	2	
	1.2	Shaft Sleeves	Set	4	
	1.3	Shaft with keys and circlips	No.	2	
	1.4	Coupling	Set	2	
	1.5	Casing Wearing rings	Set	4	
	1.6	Mechanical seals (For ACW Pumps)	Set	4	Full assembly per set
	1.7	Stuffing box Packing	Set	4	
	1.8	Gaskets	Set	1	
	1.9	Bearings	Set	4	
	1.10	Impeller wear ring	Set	4	
	1.11	RTDs / Temp. Gauge – (Bowl, Impeller Nut)	No.	See rem.	Minimum four nos. of field instruments for each type & each range or 20% of each type and each range whichever is higher
2		**PLATE TYPE HEAT EXCHANGERS**			
	2.1	Heat transfer plates (This shall include four sets of end plates and sealing plates)	No.	See rem.	10% of total no. supplied in all heat exchangers of one unit.
	2.2	Gaskets (Plate joint of heat exchanger)	Set	See rem.	Two set for all plates joint of one heat exchanger
	2.3	Post rings	No.	See rem.	50 % of total nos.
3		**VALVES**			
	3.1	Butterfly valves			
	3.2	Disc Seal	Set	2	For each valve
	3.3	Flange gasket	Set	2	For each valve

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	3.4	Seat/seal clamping bolts	No.	See rem.	20% of total nos. required
	3.5	'O' ring seals / or packing	Set	2	For each valve ["Set" refers to the total no. of the 'O" rings / packing for each valve e.g. if one valve has four "O" ring seals, one set refers to four "O" ring seals]
	3.6	Shear pins	Set	2	For each valve
	3.7	Other valves	No.	See rem.	20% of total quantity for each type, size & material
4		**EXPANSION JOINTS**			
	4.1	Control Unit consisting of stretcher bolt, nuts, steel washer for each expansion joint	Set	2	
5		**FASTENERS**			
	5.1	Fasteners shall include lock washers and lock nuts	No.	See rem.	20% of total quantity for each type, size & material
H		**COMPRESSED AIR SYSTEM AND A/C AND VENTILATION SYSTEM**			
1		**Centrifugal Fan**			
	1.1	Motor Bearing	Set	4	For each type and size
	1.2	Fan Bearing	Set	4	For each type and size
	1.3	V-Belt	Set	2	For each type and size
	1.4	Vibration Isolators	Set	2	For each type and size
	1.5	Shaft Seal	Set	2	For each type and size
2		**Axial /Propeller Fans**			
	2.1	Motor Bearing	Set	4	For each type and size
3		**Roof Extractor Fans**			
	3.1	Motor Bearing	Set	2	For each type and size
4		**Centrifugal Pump**			
	4.1	Motor Bearing	Set	2	For each type and size
	4.2	Pump Bearing	Set	2	For each type and size
	4.3	Wear Ring	No.	4	For each type and size
	4.4	Gasket	No.	4	For each type and size
5		**Air Washer**			
	5.1	Suction Screen	No.	8	
	5.2	Spray Nozzles	No.	1000	
	5.3	Flooding Nozzles	No.	50	
6		**Air Handling Units (AHU)**			

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	6.1	V-Belts	Set	4	For each type, rating and size
	6.2	Motor Bearing	Set	4	For each type, rating and size
	6.3	Fan Bearing	Set	4	For each type, rating and size
	6.4	Filters	Set	4	For each type, rating and size
7		**Fan Coil Unit (FCU)**			
	7.1	Motor Bearing	Set	4	For each type, rating and size
	7.2	Filters	Set	4	For each type, rating and size
8		**Gate/Globe Valve**			
	8.1	Renewable Seat	No.	2	For each type, rating and size
	8.2	Stuffing Box Packing/O Ring	No.	2	For each type, rating and size
	8.3	Shaft Bearing	No.	2	For each type, rating and size
9		**Butterfly Valve**			
	9.1	Renewable Seat	No.	2	For each type, rating and size
	9.2	Stuffing Box Packing/O Ring	No.	2	For each type, rating and size
	9.3	Shaft Bearing	No.	2	For each type, rating and size
	9.4	SS Seat	No.	2	For each type, rating and size
	9.5	Dowel Pin	No.	2	For each type, rating and size
	9.6	Pins & Screw for valve internal replacement	No.	2	For each type, rating and size
I		**ELECTRICAL ITEMS**			
1		**Isolated Phase Bus Duct**			
	1.1	Bus support and Phase shorting bar insulator	Sets	2	Each set shall consist of 10% of total quantity of each type of bus duct insulators used in both the units.
2		**Set consisting of one number of each type Seal-off bushing for following:**			
	2.1	Main IPBD indoor portion	Sets	2	
	2.2	Main IPBD outdoor portion	Sets	2	
	2.3	Delta IPBD	Sets	2	
	2.4	Tap-off IPBD	Sets	2	
3		HV Fuse	Nos.	6	
4		LV Fuse and MCB of each type and rating	Nos.	See rem.	3 nos. of each type and rating of LV fuse and MCB shall be supplied as spare
5		**Set of copper flexible (bus bar/ terminal) connectors rated to carry full design phase current required at one phase connection at Generator end, GCB end, GT end, UT end, VTSP Cubicles end, NGT and NGR end**			All contact surfaces shall be silver plated with minimum 5 micron thickness

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	5.1	Main IPBD section	Sets	2	
	5.1.1	Generator phase terminal connection			Each set shall consist of required number and corresponding area of copper flexible required for single phase connection
	5.1.2	Generator neutral terminal connection			
	5.1.3	GCB terminal connection towards Generator side			
	5.1.4	GCB terminal connection towards GT side			
	5.2	Delta IPBD section	Sets	2	Each set shall consist of required number and corresponding area of copper flexible required for termination of IPBD on one phase GT bank.
	5.3	Tap-off IPBD section			
	5.3.1	UT terminal connection	Sets	2	Each set shall consist of required number and corresponding area of copper flexible required for single phase connection
	5.3.2	VTSP (Generator side) terminal connection	Sets	2	
	5.3.3	VTSP (GT side) terminal connection	Sets	2	
	5.3.4	NG cubicle terminal connection	Sets	2	
6		**Set of Welded Aluminum Flexible connectors for Expansion joint for one phase, rated to carry full design phase current required for entire length of Main , Delta and Tap-off IPBD**			
	6.1	Main IPBD section			
	6.1.1	Main IPBD indoor portion	Sets	2	Each set shall consist of required number and corresponding area of Aluminum flexible laminations required for single phase connection
	6.1.2	Main IPBD outdoor portion	Sets	2	
	6.2	Delta IPBD section	Sets	2	Each set shall consist of required number and corresponding area of Aluminum flexible laminations required for single phase connection in delta IPBD section

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	6.3	Tap-off IPBD section	Sets	2	Each set shall consist of required number and corresponding area of Aluminum flexible laminations required for single phase connection in tap-off IPBD section
7		**Set of Bolted Aluminum connectors for one phase, rated to carry full design phase current required for entire length of Main , Delta and Tap-off IPBD**			
	7.1	Main IPBD section			
	7.1.1	Near Generator phase side CT (if provided)	Sets	2	Each set shall consist of required number and corresponding area of Aluminum strips required for single phase connection
	7.1.2	Near Generator neutral side CT (if provided)	Sets	2	
	7.1.3	Phase shorting bar	Sets	2	
	7.1.4	Main IPBD indoor section (if provided)	Sets	2	
	7.1.5	Near Wall frame assembly	Sets	2	
	7.2	Delta IPBD section	Sets	2	Each set shall consist of required number and corresponding area of Aluminum strips required for single phase connection near GT termination (if provided)
	7.3	Tap-off IPBD section	Sets	2	Each set shall consist of required number and corresponding area of Aluminum strips required for single phase connection near CT at UT termination.
8		Set consisting of each type and size of Gasket	Sets	2	Each set shall consist of 10% length of each type and size of gasket used in overall IPBD and its accessories (including HAB, Pressurization, NGC, VTSP, Terminations etc.) for both units
9		**Set consisting of metallic/rubber bellows consisting of two nos. of each type (Main, Delta tap off and GCB)**			
	9.1	Main IPBD section			
	9.1.1	Metallic bellow for IPBD enclosure connection to GCB	Sets	2	Each set shall consist of 2 nos. of metallic/rubber

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
		(generator side)			bellows for single phase connection
	9.1.2	Metallic bellow for IPBD enclosure connection to GCB (GT side)	Sets	2	
	9.1.3	Rubber bellow for IPBD enclosure connection to generator phase adopter box	Sets	2	
	9.1.4	Rubber bellow for IPBD enclosure connection to generator neutral adopter box	Sets	2	
	9.2	Delta IPBD section			
	9.2.1	Rubber bellow for IPBD enclosure connection to Generator transformer adopter box.	Sets	2	Each set shall consist of 2 nos. of metallic/rubber bellows for single phase connection
	9.3	Tap-off IPBD section			
	9.3.1	Rubber bellow for IPBD enclosure connection to Unit transformer adopter box.	Sets	2	Each set shall consist of 2 nos. of metallic/rubber bellows for single phase connection
10		Drain plug, if provided	Sets	8	Each set shall consist of one Drain plug with required hardware (gasket ring, nut , bolt etc.) required for mounting
11		Bellville washer of each size	Sets	2	Each set shall consist of 10% quantity of each size of Bellville washer used for both the units
12		Capacitor	Nos.	2	
13		Surge arrester	Nos.	2	
14		Voltage transformers	Sets	2	Each set shall consist of one number of single phase VT of each type (Type differentiation as per VT secondary class)
15		Current transformers	Sets	2	Each set shall consist of one number of single phase CT of each type and rating
16		Silica gel breather, if provided	Sets	2	Each set shall consist of one silica gel breather with required hardware (bush, pipe

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
					, nut etc.) required for mounting
17		Hardware (Hex screw, plain washer, punched washer, screw, helical spring, hex nut etc.)	Sets	2	Each set shall consist of 10% quantity of each size of Hardware used for both the units including that used in all panels (HAB, Pressurization panel, NGC, VTSP etc.)
18		Insulating sleeve for bolts	Sets	2	Each set shall consist of 10% quantity of each size of insulating sleeve used for both the units
19		Insulating pads for enclosure supports	Sets	2	Each set shall consist of 10% quantity of insulating pads used for both the units
20		SS clip for rubber bellow if used	Sets	2	Each set shall consist of one number of SS clip along with tightening hardware for each section of bus duct i.e. Main, Delta and Tap-off respectively
21		Earth braid	Sets	2	Each set shall consist of 10% quantity of earth braid (used for panel doors) used for both the units
22		Surge Counter	Nos.	2	
23		Bolted copper bus bar piece for CT-10 mounting in NGC	Nos.	1	The length, area and material shall be same as used in NGC
24		Insulating flap at generator termination	Nos.	1	The material, size and length shall be same as used for connection to generator flange in approved drawing
25		**Spares for pressurization system :**			
	25.1	Compressor motor	Nos.	2	
	25.2	Air compressor	Nos.	2	
	25.3	Set consisting of each type of Valve	Sets	2	Each set consist of one number of each type of valve (like Isolating valve, control valve, main control valve, solenoid valve, niddle valve, non-return valve, spring loaded release valve, pressure

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
					reducing valve, purge valve etc.) used in approved pressurization scheme
	25.4	Set consisting of one number of each type of Pressure gauge	Sets	2	
	25.5	Set consisting of one number of each type and rating of Pressure switch	Sets	2	Differential pressure switch also included here
	25.6	Adsorber used in the air dryer	Lot	2	One lot consist of quantity required for two columns
	25.7	Set consisting of one number of each type and rating of Power Contractors	Sets	2	
	25.8	Set consisting of one number each type and rating of Control Contractors/auxiliary relays, MCBs, isolating switches, selector switches	Sets	3	
	25.9	Set consisting of one number each type and rating of timers	Sets	2	Like Air dryer timer, purge timer etc.
	25.10	Set consisting of one number of each type, colour and rating of Indicating lamp	Sets	3	
	25.11	After cooler	Nos.	1	
	25.12	Set consisting all types of filters	Sets	1	Each set consist of total quantity of each type of filter (like pre filter, carbon filter, after filter etc.) as used in pressurization system of one unit.
	25.13	Flow indicator	Nos.	1	
	25.14	Temperature indicator	Nos.	1	
	25.15	Pressure Transducers	Sets	1	Set consist of one number of each type and rating of pressure transducer
	25.16	Ammeters	Nos.	2	One number of single phase ammeter
	25.17	Digital pressure indicator an control unit	Nos.	1	

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
26		**Spares for Hot air blowing system**			
	26.1	Air blower	Nos.	2	
	26.2	Driver motor	Nos.	2	
	26.3	Temperature controller (Thermostat)	Nos.	2	
	26.4	Set consisting of one number of each type and rating of Power Contactor, isolating switches, indicating lamps, fuses/MCBs, selector switches, push buttons, OLR, SFU.	Sets	2	
	26.5	Heater element	Nos.	3	
	26.6	15 meters Flexible hose connection with couplings at both ends	Nos.	2	
	26.7	Filter element	Sets	1	Each set consist of total quantity of filter element used in HAB system of single unit
	26.8	Set consisting of Flexible connectors for earthing	Nos.	6	
	26.9	Castor wheels	Nos.	4	
	26.10	Cover/Sealing plate at IPBD inlet connection	Nos.	3	
	26.11	Current transformer	Nos.	2	Single phase CT
	26.12	Ammeter	Sets	1	Each set consist of either one three phase ammeter or two single phase ammeter
27		**Generator Circuit Breaker (GCB)**			
	27.1	Single phase pole assembly with GCB series isolator, earth switches, capacitor (if provided) with enclosure complete with all accessories as required in operational GCB pole.	Nos.	2	
	27.2	Set consisting of Support Insulators (Consisting of two numbers of each type)	Sets	2	Including cooler insulators
	27.3	Hydraulic pump/spring charging motor for GCB	Nos.	2	
	27.4	Closing coils	Nos.	4	
	27.5	Tripping coils	Nos.	4	

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	27.6	Set consisting of each type of Gasket	Sets	4	Each set shall consist of 25% quantity of each type of gasket used in single unit of 3-Pole GCB along with all it panels and accessories
	27.7	Set consisting of each type of Sealing rings and O-rings	Sets	4	Each set shall consist of 25% quantity of each type of sealing ring and O-rings used in single unit of 3-Pole GCB along with all it panels and accessories
	27.8	Set consisting of each type of Misc. mechanical parts	Sets	2	Each set shall consist of all mechanical parts (like operating shaft, rod linkage, operating lever, control lever etc.) for complete operation of 3-Poles of breaker , disconnector and earth switches
	27.9	Set consisting of each type of Auxiliary contact assembly	Sets	1	Set shall consist of total number of each type and rating of auxiliary contacts used in single unit of 3-pole GCB.
	27.10	Set consisting of each type of Fuses/MCB, auxiliary contactor, auxiliary relays and bulbs for indicating and annunciation lamps on LCP	Sets	1	Set shall consist of total number of each type and rating of fuses, MCBs, auxiliary relays, auxiliary contactors, indicating lamps, annunciation lamps used in single unit of 3-pole GCB.
	27.11	Set consisting of each type of Logic cards on LCP	Sets	2	Set consist of one number of each type of logic card
	27.12	Set consisting of 10 % of Connecting hardware for GCB terminals	Sets	2	Each set shall consist of 10% of each type and rating of terminals used
	27.13	Set consisting of Indicating lamp covers provided in LCP consisting of 5 Nos. of each type	Sets	2	
	27.14	Set consisting of Instruments on LCP consisting of one number of each type and rating	Sets	2	
	27.15	Drive motors for series isolator	No.	1	

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	27.16	Set consisting of Moving contact assembly for three poles of series isolator	Set	1	
	27.17	Set consisting of fixed contact assembly for three poles of series isolator	Set	1	
	27.18	Drive motor for generator side earth switch	No.	1	
	27.19	Set consisting of Moving contact assembly for three poles of generator side earth switch	Set	1	
	27.20	Set consisting of fixed contact assembly for three poles of generator side earth switch	Set	1	
	27.21	Drive motor for GT side earth switch	No.	1	
	27.22	Set consisting of Moving contact assembly for three poles of GT side earth switch	Set	1	
	27.23	Set consisting of fixed contact assembly for three poles of GT side earth switch	Set	1	
	27.24	Capacitor (if provided) for GCB	Nos.	3	3 nos. of single phase unit of capacitor shall be provided of each rating respectively
	27.25	Set consisting of SF-6 gas cylinders (10% of the total volume required for filling three poles of one breaker)	Sets	2	
	27.26	Set consisting of instruments like pressure switches, pressure gauges consisting three of each type	Sets	2	
	27.27	Axial Cooling Fans (Complete unit which can be mounted as such)	Nos.	6	
	27.28	Centrifugal Cooling Fans (Complete unit which can be mounted as such)	Nos.	4	
28		**415 V Motor Control Centre (MCC) and Power cum Motor Control Centre (PMCC) (Both/Two sets consists of 5 % of total items listed below in all eight Cl-IV MCCs and four Cl-III PMCCs of both the units respectively subject to a minimum of 2 numbers)**			

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	28.1	Contactors of each rating	Sets	2	Including all add-ons, additional contacts, mechanical interlocks etc.
	28.2	MCCBs of each rating	Sets	2	Including all add-ons, additional contacts, additional modules etc.
	28.3	Switch-fuse assemblies of each rating	Sets	2	Includes additional auxiliary contacts
	28.4	HRC fuse cartridges with base of each rating	Sets	2	Includes power and control circuit fuse
	28.5	Overload relays of each type and rating	Sets	2	Includes reset cord and terminal block for clip on mounting
	28.6	Auxiliary relays of each type and rating	Sets	2	Includes diodes
	28.7	Earth fault CT of each rating	Sets	2	
	28.8	Bus bar insulators of each type	Sets	2	
	28.9	Control transformers of each rating	Sets	2	
	28.10	Voltage transformers of each rating	Sets	2	
	28.11	Voltmeters	Sets	2	
	28.12	Indicating lamps of each rating and colour	Sets	2	
	28.13	Running time meters	Sets	2	
	28.14	5% of externally supplied extra modules fully wired, roughly distributed across all types and sizes. The selection of fully wired spare MCC modules shall be as per approval of NPCIL	Sets	2	
	28.15	5% of extra modules, fully wired, roughly distributed across all types and sizes provided in the MCC itself. The selection of these fully wired spare MCC modules shall be as per approval of NPCIL	Sets	2	
	28.16	5% vacant space inside MCC for installation of externally supplied spare modules in future if need arises.	Sets	2	
29		**Elevators (The total quantity to be supplied in two sets shall be equal to the total quantity used in a single elevator for each type and rating of component)**			

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	29.1	Complete set of brake shoe liners, brake contact, contact finger, power and control contactor, car guide shoe liners, lead switch for floor select, cut off switch, push button elements, indicating bulbs, landing door contacts, landing door lock mechanism and landing door operation chain suitable for capacity of 20 persons (1360 Kg)	Sets	2	
	29.2	Complete set of brake shoe liners, brake contact, contact finger, power and control contactor, car guide shoe liners, lead switch for floor select, cut off switch, push button elements, indicating bulbs, landing door contacts, landing door lock mechanism and landing door operation chain suitable for capacity of 8 persons (554 Kg)	Sets	2	
30		**Illumination System**			
	30.1	Two set consists of 10% of Lighting fixtures of each type (as used in both the units) subject to minimum of 2 numbers of each type	Sets	2	
	30.2	Two set consists of 10% of receptacle of each type (as used in both the units) subject to minimum of 2 number of each type.	Sets	2	
31		**AC Distribution boards for lighting, Spare Heater and Ventilation Distribution boards**			

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	31.1	Two set consists of 10% of each type and rating of components provided for lighting & receptacle boards, space heater boards and ventilation distribution boards (for both the units) like MCCBs, HRC fuses, contactors, neutral links, MCBs, control switches, LED indicating lamps, SFUs, RCCBs, MPCBs, relays and any other individual component used subject to a minimum of 5 numbers of each type.	Sets	2	
32		**HV Motors (PC-E-503)(for each Type and Rating of motor)**			
	32.1	Complete bearing assembly for drive and non-drive ends	set	1	
	32.2	Spare motor	nos.	1	
	32.3	space heaters	set	1	Including both at driving and non-driving end
	32.4	Wherever provided, speed sensor, speed processing equipment along with alarm and trip contacts	set	1	
	32.5	Winding and Bearing RTDs	no.	1	of each type
	32.6	Shaft insulating sleeve (to prevent shaft current)	no.	1	Wherever applicable
	32.7	CTs for differential protection if provided	set	1	
	32.8	Seals, gaskets, O' rings and other materials	set	1	(If required for periodic replacement)
	32.9	Terminal bushings	Nos.	6	
	32.10	Condition monitoring instrumentation (i.e. sensors along with signal conditioning unit for vibration in all three directions along with phase angle measurements, motor current measurement, speed measurement, reverse rotation detector measurement, motor cooler leakage detector	set	1	

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
		measurement etc.)			
33		**MEDIUM VOLTAGE MOTORS OF CAPACITY GREATER THAN 50 kW (PC-E-502) (for each Type and Rating of motor)**			
	33.1	Complete bearing assembly	set	1	At both Driving End and Non-Driving End
	33.2	Space heaters	set	1	Including both at driving and non-driving end
	33.3	Winding & Bearing RTDs	no.	1	of each type
	33.4	Seals and other materials	set	1	(If required for periodic replacement)
34		LV Motors Less than 50 KW(PC-E-501) (for each Type and Rating of motor)			
	34.1	Complete bearing assembly for drive and non-drive end bearings	set	1	
	34.2	Spare motor	Nos.	1	
	34.3	Space heaters wherever provided	set	1	Including both at driving and non-driving end
	34.4	Seals and other materials	set	1	(If required for periodic replacement)
J		**C&I ITEMS**			

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
1.		Field instruments (e.g. PTs, DPTs, LTs, RTDs, Thermocouples, Guided wave radar, magnetic level gauge, reflex type level gauge, Averaging Pitot Tube, In line conductivity cells, Temperature Transmitters, Conductivity transmitters, gauges, Switches for: temperature, pressure, level, flow etc.), limit switches for valves, limit switches & torque switches for motorized valves, position transmitters for control valves, etc. for all systems supplied under TIP.	Nos.	See rem.	Minimum 2 nos. of field instruments for each type & each range or 20% of each type and each range whichever is higher
2.		Probes and electronic modules for Ultrasonic Flow Meters for all systems supplied under TIP.	Nos.	See rem.	Minimum 2 nos. for each type or 20% of each type whichever is higher
3.		Relays, indicating lamps, indicators, Panel indicating meters, MCBs and fuses, Hand switches, Push buttons, Loose electronic components not mounted of PCB (such as capacitor, choke, diodes etc.) for all systems and equipment (e.g. DCS panels, PLC panels, Profibus panels, Electrical valve actuators, etc.) supplied under TIP.	Nos.	See rem.	Minimum 2 nos. for each type or 20% of each type whichever is higher
4.		Electronic cards/modules (such as I/O module, processor module, power supply module, interface module, communication module, signal conditioning units, signal isolator, frequency modulator, Hub, etc.) for all systems and equipment (e.g. DCS panels, PLC panels, Profibus panels, Electrical valve actuators, etc.) supplied under TIP.	Nos.	See rem.	Minimum 2 nos. for each type or 20% of each type whichever is higher. For each type of input/output module spares channels shall be provided in each rack such that provision for adding minimum 20% extra signals without adding extra modules should exist. These spare channels of modules shall be wired to terminals provided in the panel. Further in each rack 10% spares slots shall be

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
					provided for future addition of I/O modules. For LAN cables minimum 10% of total length shall be supplied as spares
5.		Instrument Support Stand (ISS), junction boxes, terminal blocks, cable glands & lugs, mounting accessories for all systems supplied under TIP.	Nos.	See rem.	Minimum 2 nos. for each type or 20% of each type whichever is higher
6.		Secondary instruments (such as E/A converter, valve positioner etc.), tube, tube fittings, 3/5 valve manifolds, instrument isolating valves, drain valves, solenoid valves, PRVs, etc. for all systems supplied under TIP.	Nos.	See rem.	Minimum 2 nos. for each type or 20% of each type whichever is higher
7.		Mounting accessories for all systems supplied under TIP.	Nos.	See rem.	Minimum 2 nos. for each type or 20% of each type whichever is higher
8.		Wired spare slots (wired to panel / JB terminals).	Nos.	See rem.	20% for future expansion
9.		I&C cables of each type	Nos.	See rem.	Minimum 10% of total length requirement.

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
10.		HMI SYSTEMS (section C-2-4-8)	Nos.	See rem.	For all individual modules of HMI, which includes apart from PCs, peripherals and other cards, interconnecting cables and power supplies a minimum of 20 % spares or 2 module/units (e.g. PC, monitor, cards of LVS & its controllers, LIU, Ethernet Switches, SMPS, Patch cords, MCBs, etc.) of each type & rating, whichever is higher shall be supplied along with the HMI system. For LAN cables minimum 10% of total length shall be supplied as spares. Detailed list of these spares shall be attached with the offer
11.		**24V DC Control Power Supply System (Section C-2-4-9-2)**			
	11.1	Populated PCBs, Electronic modules, plug-in sub-assemblies/units	Nos.	See rem.	20% of the each type or at-least two units of each type whichever is more.
	11.2	Thyristors, Transistors, IGBTs, Diodes, Bleeder resistors, etc. not mounted on the sub-assemblies/units	Nos.	See rem.	20% of the each type & rating or at-least two components each type & rating whichever is more.
	11.3	HRC fuses, Semiconductor fuses, MCCBs, MCBs	Nos.	See rem.	20% of the each type & rating or at-least two units of each type & rating whichever is more.
	11.4	AC capacitors & DC capacitors	Nos.	See rem.	20% of the each type & rating or at-least two units of each type & rating whichever is more.
	11.5	Hall sensors, CTs, Relays, Chokes, shunt, LED modules, Indicating lamps, Switches, Push buttons, timers	Nos.	See rem.	20% of the each type & rating or at-least two units of each type & rating whichever is more.
	11.6	Panel meters, 4-20 mA transducers and temperature sensors	Nos.	See rem.	20% of the each type & rating or at-least two units of each type & rating whichever is more.
12		**Lead Acid Control Battery (For 220V DC battery banks)**			

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
		(section C-2-4-9-3)			
	12.1	Inter-cell connectors.	Nos.	See rem.	10% of each type/size or minimum 2 nos., whichever is higher
	12.2	Battery stand insulators and cell insulators. (If Required)	Nos.	See rem.	10% of each type/size or minimum 2 nos., whichever is higher
	12.3	Nuts, bolts, washers, etc.	Nos.	See rem.	10% of each type or minimum 2 nos., whichever is higher
	12.4	Vent plugs.	Nos.	See rem.	10% of each type or minimum 2 nos., whichever is higher
	12.5	Complete set of spare cell without electrolyte.	Nos.	See rem.	10% of each type/rating or minimum 2 nos., whichever is higher
	12.6	Battery inter-row connector and inter stand connector	Nos.	See rem.	10% of each type/size or minimum 2 nos., whichever is higher
	12.7	End take off	Nos.	See rem.	Two of each type
	12.8	Electrolyte (of required specific gravity)	Nos.	See rem.	10% of total quantity
	12.9	Spill Tray (If required)	Nos.	10	10 Nos.
	12.10	Cell containers with lids	Nos.	See rem.	10 Nos. of each type & size
	12.11	Insulated shrouds over bare connections and	Nos.	30	30 Nos.
	12.12	Petroleum Jelly for Terminals	Nos.	See rem.	Lump sum
	12.13	Any other item	Nos.	See rem.	10% or minimum 2 nos.
13		**Lead Acid Control Battery (section C-2-4-9-3) (For 26V DC battery banks)**			
	13.1	Inter-cell connectors.	Nos.	See rem.	10% of each type/size or minimum 2 nos., whichever is higher
	13.2	Battery stand insulators and cell insulators. (If Required)	Nos.	See rem.	10% of each type/size or minimum 2 nos., whichever is higher
	13.3	Nuts, bolts, washers, etc.	Nos.	See rem.	10% of each type or minimum 2 nos., whichever is higher
	13.4	Vent plugs.	Nos.	See rem.	10% of each type or minimum 2 nos., whichever is higher
	13.5	Complete set of spare cell without electrolyte.	Nos.	See rem.	10% of each type or minimum 2 nos., whichever is higher
	13.6	Battery inter-row connector and inter stand connector	Nos.	See rem.	10% of each type/size or minimum 2 nos., whichever is

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
					higher
	13.7	End take off	Nos.	See rem.	Two of each type
	13.8	Electrolyte (of required specific gravity)	Nos.	See rem.	10% of total quantity
	13.9	Spill Tray (If required)	Nos.	5	
	13.10	Cell containers with lids	Nos.	5	
	13.11	Insulated shrouds over bare connections and	Nos.	20	
	13.12	Petroleum Jelly for Terminals	Nos.	See rem.	Lump sum
	13.13	Any other item	Nos.	See rem.	10% or minimum 2 nos.
14		Semiconductor Based Hydrogen Leak Detection System (section C-2-4-9-28)	Nos.	See rem.	20% of total quantity of sensor. 20% of total quantity of SCU.
15		Condition Monitoring System (Turbine Supervisory System (TSS) & Vibration Monitoring System (VMS)) (section C-2-4-9-29)	Nos.	See rem.	Minimum two numbers or 20% of the population (whichever is higher) for: each type of field sensors with integral cable, extension cable, monitors, power supply module, processor module, interface module, FFT analyzers card, analog signal processing I/O card, measuring attachment card, signal isolator, frequency modulator, power supply module of server, communication equipment/devices, each type of electronic/relay module (for each variety/version) used in the system, accessories, Junction boxes shall be supplied by vendor. For each type of module installed in the system 10% spare provision shall exist in the installed system so that additional inputs can be connected to these inputs without the need of installing the additional modules.

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
					Minimum 20% spare slots shall be available in the system for future expansion.
16		**220V DC Control Power Supply System (section C-2-4-9-30)**			
	16.1	PCBs, Electronic modules, plug-in sub-assemblies/units	Nos.	See rem.	20% of the each type or at-least two units of each type whichever is more.
	16.2	Thyristors, Transistors, IGBTs, Diodes, Bleeder resistors, etc. not mounted on the sub-assemblies/units	Nos.	See rem.	20% of the each type & rating or at-least two components each type & rating whichever is more.
	16.3	HRC fuses, Semiconductor fuses, MCCBs, MCBs	Nos.	See rem.	20% of the each type & rating or at-least two units of each type & rating whichever is more.
	16.4	AC capacitors & DC capacitors	Nos.	See rem.	20% of the each type & rating or at-least two units of each type & rating whichever is more.
	16.5	Hall sensors, CTs, Relays, Chokes, shunt, LED modules, Indicating lamps, Switches,	Nos.	See rem.	20% of the each type & rating or at-least two units of each type & rating whichever is

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
		Push buttons, timers			more.
	16.6	Panel meters, 4-20 mA transducers and temperature sensors	Nos.	See rem.	20% of the each type & rating or at-least two units of each type & rating whichever is more.
17		**Uninterruptible Power Supply (UPS) System (section C-2-4-9-31)**			
	17.1	Plug-in sub-assemblies/Electronic modules/populated PCBs/units	Nos.	See rem.	20% of the each type or at-least two units of each type, whichever is more.
	17.2	Thyristors modules, Transistors, IGBT modules, Diodes, Resistors, etc. not mounted on the sub-assemblies/units	Nos.	See rem.	20% of the each type & rating or at-least two numbers of components of each type & rating, whichever is more.
	17.3	Fuses, MCCBs, MCBs, Panel meters, transducers, temperature sensors	Nos.	See rem.	20% of the each type & rating or at-least two units of each type & rating whichever is more.
	17.4	AC capacitors & DC capacitors	Nos.	See rem.	20% of the each type & rating or at-least two units of each type & rating whichever is more.
	17.5	Hall sensors, Temperature sensors, CTs, Relays, Indicating lamps, Switches, Chokes	Nos.	See rem.	20% of the each type & rating or at-least two units of each type & rating whichever is more.
	17.6	Static switches modules.	Nos.	2	
18		**Control Power Supply Distribution Panel (CPSDP) (section C-2-4-9-43)**			
	18.1	Miniature Circuit breakers (MCBs)	Nos.	See rem.	Minimum 2 nos. for each type & each rating or 20% of each type and each rating, whichever is higher
	18.2	Molded case circuit breakers (MCCBs)	Nos.	See rem.	Minimum 2 nos. for each type & each rating or 20% of each type and each rating, whichever is higher.
	18.3	Ammeter	Nos.	See rem.	Minimum 2 nos. for each type & each range or 20% of each type and each range, whichever is higher.

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	18.4	CT	Nos.	See rem.	Minimum 2 nos. for each type & each range or 20% of each type and each range, whichever is higher
	18.5	Voltmeter	Nos.	See rem.	Minimum 2 nos. for each type & each range or 20% of each type and each range, whichever is higher
	18.6	HRC Fuses with holder	Nos.	See rem.	Minimum 2 nos. for each type & each rating or 20% of each type and each range, whichever is higher
	18.7	Plug in type Relays	Nos.	See rem.	Minimum 2 nos. for each type & each rating or 20% of each type and each range, whichever is higher
	18.8	Indicating Lamps	Nos.	See rem.	Minimum 2 nos. for each type & each rating or 20% of each type and each rating, whichever is higher
	18.9	Hands witches	Nos.	See rem.	Minimum 2 nos. for each type & each rating or 20% of each type and each rating, whichever is higher
	18.1	Electronic cards, modules	Nos.	See rem.	Minimum 2 nos. for each type or 20% of each type, whichever is higher
19		**Central Clock System (CCS) (section C-2-4-9-58)**			
	19.1	GPS Antenna & Driver Unit	Set	1	
	19.2	Central Controller Unit (CCU) with 2 nos. STRATUM-1 servers	no.	1	
	19.3	Operator Display Unit (ODU)	no.	1	
	19.4	NTP Servers (STRATUM-2)	nos.	2	
20		**Steam Water Analysis System (SWAS)**			

Sr. No.		Item Description	Unit of Measure	Quantity	Remarks
	20.1	Instrumentation items (e.g. isolation valves, needle valves, thermal shut off valves, pressure regulators, flow indicators, flow switches, rotameters, pressure gauges, temperature gauges, solenoid valves, temperature switches, fittings, field sensors/probes, relays, hand switches, MCBs, etc.)	nos.	See rem.	Minimum 2 nos. of each type & each range or 20% of each type and each range whichever is higher
	20.2	Coolers, Filter, Relief valve, Back pressure regulator, Columns	nos.	See rem.	Minimum 2 nos. for each type or 20% of each type whichever is higher
	20.3	Analyzers	nos.	See rem.	Minimum 2 nos. for each type & each range or 20% of each type & each range whichever is higher
	20.4	Reagents	nos.	See rem.	Minimum 2 nos. for each type or 20% of each type whichever is higher
K		**INSURANCE SPARES**			
1		H.P. Turbine bladed rotor (Insurance spare)	No.	1	**APPLICABLE FOR ALL 3 PROJECTS**
2		L.P. Turbine bladed rotor (Insurance spare)	No.	1	
3		Generator rotor (Insurance spare)	No.	1	

Note 1: Spares to be supplied should be physically interchangeable with similar components already installed/in use and shall undergo all inspections and tests as per the QAP approved for the motors ordered.

Notes 2:

1. FOB INCOTERM 2010 - "Free on Board."
2. DAP as per Incoterms 2010 stands for: The Seller delivers when the goods are placed at the Buyer's disposal on the arriving means of transport ready for unloading at the names place of destination. The Seller bears all risks involved in bringing the goods to the named place.

20.1 For all major equipment, the CONTRACTOR shall provide appropriate structural steel members for mounting various handling devices which are necessary for the dismantling and reassembly of equipment components during erection and maintenance.

20.2 The TENDERER shall indicate and include in his scope of supply all the necessary tools and tackles required for erection, maintenance and servicing of the systems, structure and equipment. The PURCHASER reserves the right to exclude any of the above items from the TENDERER'S scope of supply and effect price adjustments on the basis of the unit rates quoted by the TENDERER. Maintenance tools and tackles supplied shall be new and unused. The dispatch of tools, tackle and lifting devices shall be synchronised with the dispatch of the related system/ equipment.

20.3 The CONTRACTOR shall supply all tools and tackles maintenance clearly marked with its size and/or purpose. They shall not be used for erection purpose.

20.4 Each set of tools and appliances shall be suitably arranged in the fitted boxes of mild steel construction. The taps, stocks and dies shall be kept in approved mild steel boxes with components for individual items. If the weight of any box and its contents is such that it cannot be conveniently carried, it shall be supplied on steerable rubber tyred wheels.

20.5 Each tool box shall be fitted with a lock and two keys and shall be painted navy blue and clearly marked in white letters, with the name of the system/equipment for which the tools and tackles are intended.

20.6 The tools and tackles with the appropriate boxes are to be handed over to the PURCHASER at the time of issue of the handing over certificate.

21.1 RATING PLATE

21.1.1 Each main and auxiliary item of system/equipment shall have permanently attached to it a rating plate in a conspicuous position. This shall be of a non-corrodible material preferably 18-8 stainless steel of minimum 3mm thickness. The inscription shall be engraved in black on the plate.

21.1.2 The size of the rating plate shall depend upon space availability but should be reasonably sized for clarity and clear inscription. The size of the plate and inscriptions shall be approved by the PURCHASER. The plates shall be attached to the body of the equipment by screws.

21.2 NAME PLATE

Each item of system/equipment shall be provided with a name plate or label designating the service of the particular system/equipment. The shape and size of the plate and inscriptions shall be approved by the PURCHASER.

Such name plates shall be of 18-8 stainless steel material having engraved black lettering.

In case of electrical equipment such as circuit breakers, panels, etc., such nameplates shall be of anodized aluminum having engraved black lettering.

The name plates shall be screwed to the body of the equipment.

21.3 DANGER_BOARDS

Danger boards having information written in English, Hindi and the applicable vernacular language shall be provided on all electrical equipment with a voltage of 415V and above. The boards shall have the skull and cross bones danger sign together with the inscriptive DANGER..... VOLTS and the corresponding translations inscribed in white letters on a red background.

22.1 The CONTRACTOR shall train the PURCHASER'S engineers, supervisors, technicians in the shops, where the equipment will be manufactured and/or in their Collaborator's works and where possible, in any other plant where equipment manufactured by the CONTRACTOR or his Collaborator is under installation or test to enable those personnel to become familiar with the equipment, either at his Works or at his SUB-CONTRACTOR'S Works or at site.

22.2 The number of personnel to be trained and the period of training shall be adequate and mutually agreed upon by the PURCHASER and the CONTRACTOR.

22.3 The training shall be so oriented as to make the PURCHASER'S personnel proficient in installing/operating the Equipment.

22.4 The PURCHASER'S personnel shall also be trained for routine maintenance work and lubrication, overhauling, adjustments, testing and replacement procedures to be adopted for the equipment offered.

22.5 The CONTRACTOR shall train the PURCHASER'S personnel in carrying out minor repairs, if need arises, during the operation of the equipment.

22.6 The charges for training the PURCHASER'S personnel and the cost of training material, if any, shall be included in the price for erection, testing and commissioning.

The CONTRACTOR shall provide all necessary instruction material for the training, which shall include manuals, booklets, pamphlets, drawings, sketches, models, pictures, photos, colour slides, film, etc. All the literatures shall be in English. The training and instruction materials shall become the property of the PURCHASER.

22.7 The CONTRACTOR shall provide at no extra cost to the PURCHASER all necessary facilities and reasonable assistance as deemed necessary for the training. The travelling and living expenses of such personnel shall be borne by the PURCHASER.

22.8 CONTRACTOR shall train PURCHASER's engineers, supervisors, technicians during manufacture at shop, erection at site, commissioning of system, structure and component, to familiarize with design, manufacturing, operation and maintenance aspects of the plant under the scope.

22.9 The training shall be in the form of lectures, hands on experience, factory visit during design, manufacturing, erection, testing and commissioning. The medium of instructions for training shall be English. All the trainings shall be completed well in advance before start of commissioning activities at site. However, hands on training shall be along with the actual activity to be carried.

22.10 A comprehensive training manual in English shall be furnished by CONTRACTOR for training PURCHASER's Operation and Maintenance personnel covering all the Systems Structures and Components as per the scope.

23.0 PAINTING

23.1 The general requirements for painting of power plant piping, equipment and support structures are covered in the following paras:

23.2 All components shall be adequately protected against corrosion during manufacture, fabrication, shipment and storage by appropriate protective paint. Use of grease or oil for this purpose is prohibited.

23.3 After installation, all above ground pipework, valves, specialities, tanks, pumps and other equipment which are neither galvanised nor insulated and which are erected by the CONTRACTOR shall be painted.

23.4 All hangers and supports, including associated auxiliary steel on all pipelines including those on galvanised and insulated pipelines shall be painted.

23.5 CODES AND STANDARDS

Paints and painting work carried at site shall conform to the following codes and standards:

IS	:	5	-	Colour for ready mixed paints and enamels
IS	:	101 Part1 to9	-	Methods of sampling and test for paints, varnishes and related products
IS	:	1477 Part I&II	-	Code of practice for painting of ferrous metals in building
IS	:	2932	-	Specification for enamel, synthetic, Exterior, a) Under coating b) Finishing
IS	:	9404	-	Colour code for identification of pipelines used in thermal power plants.
PC-E-615	:			Technical specification for paints in Nuclear Power Plants.

23.6 CONTRACTOR shall satisfy himself, availability of all information in the specifications for proper selection of the paints and ensure their applications as per Codes.

23.7 Surface Preparation

The surfaces to be painted shall be thoroughly cleaned of all grease, oil, and loose mill scale, dirt, rust and any other foreign matter. Cleaning at shop shall be carried out by thoroughly shot blasting the surface. However mechanical cleaning at site by power tool scraping with steel wire brushes shall preferably be adopted to clean the surface to the entire satisfaction of PURCHASER. However, in certain locations where power tool cleaning cannot be carried out abrasive paper can be used.

23.8 Primer Painting

a) After surface preparation, two coats of epoxy resin based zinc rich primer or any suitable primer for the environment, service and compatible with finish paint requirement shall be applied. Dry film thickness of each coat shall be as per the recommendations of primer/paint manufacturer. Primer shall be applied by either spraying or brushing ensuring a continuous film without “holidays”. Primer coat shall be immediately applied without any time lag after the surface preparation.

b) Any equipment, which has been given the shop coat of primer after its erection in the field, shall be carefully examined and where ever the primer coat is damaged shall be recoated with primer. However over the field welds, bolts and nuts, etc. two primer coats as per (a) shall be applied.

c) The type of primer and manufacturer shall be as approved by the PURCHASER.

23.9 Finish Painting

a) After the primer coat has dried out, the surface shall be cleaned of dust, without scratching or in any way damaging the primer coats. Over this dry surface finish painting shall be carried out.

b) CONTRACTOR shall select the paint suitable for environment, service and compatible with primer applied. However the type of paint, manufacturer and colour / shade shall be as approved by the PURCHASER.

c) Finish painting shall be carried out in two coats. Dry film thickness of each coat shall be as per the recommendations of primer/paint manufacturer.

d) Paint shall be applied either by brushing or spraying. It shall be ensured that brush marks are a minimum and the requirements of workmanship are as specified in IS: 1477(for site painting works on systems , structures and components).

e) Paint used shall be stirred frequently to keep the pigment in suspension. Paint shall be of the ready mixed type in original sealed containers as packed by the paint manufacturer. Addition of thinners shall not be permitted.

f) No painting shall be done in frost / foggy weather or when the humidity is high enough to cause condensation on the surface to be painted. Paint shall not be applied when the temperature of the surface to be painted is 5 Deg. C or below.

23.10 Other Requirements

a) Paint/primer manufacturer's instructions shall be followed in method of application, handling, drying time, dry film thickness etc.

b) The colour of each coat of paint shall be of slightly differing shade with that of previous coat.

c) The colour of the finish paints shall be as per PURCHASER's colour scheme, which would be furnished to the CONTRACTOR after award of contract.

d) In case finish paint is applied in shop, one coat of finish paint shall be applied at site, if directed by PURCHASER. Before applying the site finish paint, it shall be spot checked for reactions with the original paint. The paint shall be of similar nature as original paint of equipment manufacturer.

e) Protection of other surfaces adjacent to the surface being painted, is the responsibility of the CONTRACTOR.

f) Following surfaces shall not be painted:

i) Valve stems, pump shafts, gauges, etc

ii) Bearing surfaces

g) The dry film thickness of the finish paint shall not be less than paint/primer manufacturer's recommendations.

h) Heat resistant paints shall be used for surfaces whose temperature is more than 50 Deg. C.

i) Paints shall be stored in such a manner as to avoid exposure to adverse weather conditions and extreme temperature conditions.

23.11 **Inspection & Testing**

a) All painted surfaces shall be visually checked for uniformity.

b) The thickness of coating of paint shall be measured.

23.12 **Colour Code for Identification**

a) All pipelines shall be colour coded for identification as per PURCHASER colour scheme which will be furnished to the CONTRACTOR after award of contract.

23.13 Painting procedure including surface cleaning and primer application shall be submitted by the CONTRACTOR for **PURCHASER approval**

24.0 PACKING

24.1 All Equipment/material shall be protected for ocean shipment/inland transport as the case may be, carriage at the Site and outdoor storage during transit and at the Site, strictly according to the instructions given in this specification.

24.2 The CONTRACTOR shall pack the Equipment at his own cost sufficiently and properly to ensure that they are free from loss or damage while in transit to the ultimate destination.

24.3 The CONTRACTOR shall be responsible for any damage to the Equipment during transit and storage in all climatic conditions due to improper and inadequate packing.

24.4 Only packages constructed out of sound material and of dimensions proportional to the size and weight of contents shall be used. Each package shall be limited to the size and weight that are permissible under existing sea/rail/road transport limitations as the case may be.

24.5 Bundled materials shall be strapped rigidly with steel band over the protective covering.

24.6 Fragile materials shall be securely braced within the containers or otherwise amply fastened and packed to prevent shifting or rattling. Soft non-hygroscopic packing materials shall be placed between the hard packing materials and the fragile Equipment. Articles which do not completely fill the selected container must be cushioned, braced, fastened or blocked to prevent damage to the article itself or destruction of the container. Inner bracing or blocking must be such that the content's weight is distributed uniformly over the entire interior surfaces rather than concentrate on one or two critical points.

24.7 Loose material, e.g. bolts, nuts, etc., shall be packed in gunny bags and sealed in polythene bags with proper tagging.

24.8 Components containing glass shall be carefully covered with shock absorbing protective material such as expanded polystyrene (Thermocole).

24.9 All flanges and similar surface which are prone to scratching shall be provided with either metal or wooden caps bolted in place. Metal caps should have a minimum thickness of 3 mm and wooden caps should be made from two layers of wood, each of 10 mm thickness, nailed together with the grain of each layer located at right angles to the other.

24.10 All openings in the Equipment shall be tightly covered, plugged or capped to prevent foreign material from entering.

24.11 In the case of large and bulky Equipment, the CONTRACTOR shall be responsible for ascertaining transport limitations and supply the Equipment in the minimum number of components or sub-assemblies, within the framework of transport limitations.

24.12 Wherever necessary, proper arrangement for attaching slings for lifting shall be provided on the packages.

24.13 The contents of the packages shall be sealed in thick polythene sheets and all the inside walls of the packages shall be lined with waterproof paper to protect the Equipment from damage due to dust and moisture.

24.14 All Equipment shall be protected for the entire period of despatch, storage and erection, against corrosion, incidental damage due to vermin, sunlight, rain, high temperature, humid atmosphere, rough handling in transit, and storage in the open including possible delays in transit. Material and Equipment shipped across the sea shall be packed to withstand without damage, the effects of salt spray. All machined and plated parts shall be protected with anti-rust grease. Precautions shall be taken to protect shafts and journals where they rest on wooden or other supports likely to contain moisture. At such points, wrappings impregnated with anti-rust composition or vapour phase inhibitors shall be used. These shall have sufficient strength to resist chafing and indentation due to the movement which is likely to occur in transit. The protective wrappings and impregnation shall last for a minimum period of three months.

24.15 Instrument connections shall be plugged with suitable caps to avoid ingress of dust and moisture during shipment and storage. Silica-gel or approved equivalent moisture absorbing material in small cotton bags shall be placed and tied at various points on the Equipment, in package wherever necessary.

24.16 Adequate provision of skids or pallets shall be made to keep the packages above the collecting drainage. Crates and other large containers should have drain holes in the bottom to prevent collection of water within the packing. This is especially important where the cargo itself is subject to condensation (cargo sweat).

24.17 All cases, where applicable, shall be provided with suitable cutouts, closed by bolted wooden planks to facilitate inspection by customs authorities. Waterproof transparent papers shall be provided at the cutout locations to prevent water ingress into the casing through the cutout.

24.18 Each package shall contain a Packing Note quoting Contract number and date, copy of Shipping Release and one set of test certificates. Copies of the Packing Note, in triplicate, shall be forwarded to the PURCHASER prior to dispatch. Each package shall be marked with name and address of the consignee, dimensions, weight, lifting points and special handling instructions, if any.

24.19 All spare parts shall be packed and treated for long storage conditions at site.

24.20 The PURCHASER may require to inspect and approve the packing before the items are despatched. However, the CONTRACTOR shall be entirely responsible for ensuring that the packing is suitable for the mode of shipment and such inspection will not exonerate the CONTRACTOR from any loss or damage due to faulty packing.

24.21 Any material found short inside the intact packing cases shall be supplied by the CONTRACTOR at no extra cost to the PURCHASER.

24.22 All packing cover and packing material shall become the property of the PURCHASER.

24.23 For Electrical Equipment Only

24.23.1 Transformers rated 2000 KVA and less shall be shipped with oil. Transformers rated more than 2000 KVA shall be shipped without oil but with the tank filled with nitrogen or equivalent inert gas. A gas cylinder with suitable reducer connection and pressure gauge shall be supplied. These accessories shall become the property of the PURCHASER. The required quantity of oil shall be supplied separately in non-returnable drums.

24.23.2 Switchgear cubicles shall be packed and shipped in separately and convenient sections. All withdrawable equipment like circuit breakers and circuit breaker arc chutes shall be packed and shipped separately. All relays and instruments shall be packed and shipped separately with their operating mechanism temporarily arrested from movement, for transport purposes.

24.23.3 Batteries shall be shipped to site in dry, uncharged condition. Appropriate quantity of acid of the correct specific gravity shall be shipped separately in non-returnable porcelain jars packed in steel wire baskets.

24.23.4 Cables shall be shipped in non-returnable drums, adequately braced and with cable ends adequately sealed to prevent ingress of moisture.

24.24 For Electronic Cabinets

24.24.1 Electronic cabinets shall be packed without withdrawable modules. The modules shall be packed separately, each module being fully enclosed with polythene to prevent moisture/dust ingress.

24.24.2 Silica gel or equivalent moisture absorbing material in small cotton bags shall be placed and tied at suitable locations within each cabinet.

24.24.3 Any loose cables/plug connections shall be suitably tied inside the cabinet to prevent hitting cabinet body during transportation. Plug connections shall be covered with PVC sheets.

24.24.4 Cabinet doors shall be locked and keys in plastic bag shall be attached to outer surface so as to be prominently visible.

24.24.5 Any lamps/switches/handles etc. provided on outer surface shall be adequately protected before cabinet is packed.

24.24.6 Each cabinet shall be packed in Aluminium foil/PVC sheet bag completely sealed to prevent moisture/dust ingress. The outer packing shall be wooden.

24.24.7 Where two or more cabinets are to be joined at site, each cabinet shall be provided with a temporary sheet metal side cover plate and packed separately.

24.25 MARKING

24.25.1 All packages shall be clearly, legibly and durably marked with uniform block letters with waterproof paint on at least three sides with:

a) Destination address as communicated
b) Contract No. and Date
c) Dimensions of crate
d) Net and gross weights
e) Sign showing 'side up'
f) Sign showing 'fragile' marks in case of delicate Equipment.
g) Sign showing slinging and sling position
h) Any handling and unpacking instructions, if considered necessary.
i) Identification mark relating them to the appropriate shipping documents.
j) In case of spare parts, each spare part shall be clearly marked and labeled on the outside of its packing with its description and catalogue/part number.
k) Any other necessary data to identify the Equipment and relate it to Contract.

24.25.2 Each package shall contain a packing note specifying the name and address of the CONTRACTOR, the number and date of the Contract/Purchase Order, name and address of consignee, description of the material and the quantity contained in such package.

24.25.3 The contents of the package shall be punched on non-corrosive metal plate and nailed to the package in a prominently visible place. If the number of items in the package is too many, a typed list in transparent water proof bag shall be kept inside a galvanised steel sheet pocket nailed on to the outside of package in prominently visible location.

24.25.4 Erection Marks

All Equipment comprising multipart assemblies, e.g. steel frame works, piping, etc., shall be marked with identifying numbers, metal marks and/or letters corresponding to those of the approved drawings or material lists. These erection marks shall be clearly readable. Colour banding to an approved code shall be employed to identify members of similar shape or type but of different strengths or grades.

25.0 GENERAL

25.1 All the shipments shall have the storage instructions for storage at site from the manufacturer.

25.2 CONTRACTOR shall identify all heavy and Over Dimensional Consignments (ODC) as per Indian motor vehicle act and all arrangements required for transportation either by sea/road/rail of all heavy and over dimensional consignments shall be made by CONTRACTOR. Details of all heavy and over dimensional consignments and transport plan shall be worked out by CONTRACTOR and submitted to the PURCHASER for information. In his bid CONTRACTOR shall identify all such consignments.

Transportation of all heavy and Over Dimensional Consignments (ODC) shall be planned by CONTRACTOR well in advance and any limitation shall be taken care of. All arrangements and procedures of transportation of over dimensional consignments from works to site are in scope of CONTRACTOR. The CONTRACTOR shall note the following regarding all heavy and ODC.

Selection of heavy & ODC Transporter: All heavy and ODC equipment shall be transported using Hydraulic Trailer of Gold hofar / Necholes/ Commetto make only. The prime mover used for the transportation shall be of 440 V HP Volvo. The CONTRACTOR shall also ensure the availability of additional prime mover during transportation when required. Also CONTRACTOR shall ensure the maximum axle load shall not be more than 16T/axle including dead load. Axles /Trailers used for transportation shall not be older than 12 years from the date of transportation.

Road Route Survey: Depending on the loaded weight and dimensions of consignment and tractor trailer proposed by transport contractor, the transport contractor/manufacturer shall survey the various available routes and come out with best and shortest possible route involving minimum infringements and improvements. The transport contractor shall submit detailed survey report of the route indicating details of cross drainage(CD) works, road geometries, any infringements, overhead electrical power lines & P&T lines shutdowns, removals of level crossing, clearance under the Rail/road/foot over bridges, etc. The detail of CD works should be given. The survey report shall include photographs of Culverts, Rail/Road Over Bridge (ROB), Foot Over Bridge (FOB), Bridges etc. en-route. The manufacturer shall select the route for safe transportation based on the route survey and ascertain the feasibility of the route for transportation. The proposed route for the road transportation showing the major towns/cities & distances, along with the route map shall be submitted.

Removal of infringements and development of infrastructure: To facilitate transport from manufacturing place to project site and based on detailed survey it is the responsibility of

the CONTRACTOR to carry out all temporary / permanent improvements in infrastructure to name a few 1. Tree trimming 2. Electrical Shutdowns 3. Improvement in road geometries 4. CD Works supporting. 5. Bypass roads 6. Parking Places 7. Removal of electrical poles, lines 8. Fencing 9. Dip filling 10. Parapet removal – level crossing height gauge and barrier poles removal etc. 11. improvements to jetty including dredging and improvements at port premises etc. and 12. all other removal, improvement etc. In short, CONTRACTOR shall be responsible for all kinds of improvements required on the route to facilitate the safe delivery of the all heavy and ODC to project site. The CONTRACTOR may list out all these improvements.

The contractor/manufacturer shall arrange permission for the movement of consignment from all concerned authorities like railway – electricity boards – Regional Transport Office (RTO) – Public Works Department (PWD)/Highway, Forest departments – Police – Port authorities – Maritime authorities etc. for safe and trouble free transport of equipment. The Package CONTRACTOR shall be responsible for any delay/damage/loss occurred to any property en-route during the movement due to non availability of any such permission or otherwise.

Convoy Programmes: In case of road movement the CONTRACTOR shall provide detailed convoy programme indicating planned daily travel – places of halt, total time required, security arrangements etc.

Convoy Formation : The consignment transported by road shall move as a convoy with a pilot jeep in front – lead vehicle – consignment tractor trailer & pusher trailing vehicle and vehicle for Package CONTRACTOR's representative who shall accompany the convoy through out till delivery of equipment at project site. The Package CONTRACTOR shall ensure that his transporter carry all required spares, tools and manpower to arrange for any trouble shooting en-route. He shall further make necessary arrangements to get Power Oil and Lubricant (POL) filled without taking consignment to petrol pump or detaching prime mover. The convoy should be equipped with proper flags (red and green) and night lamps to ensure safety of consignment while moving on road. One standby prime mover shall always be available with the Trailer convoy.

Duration of movement : The convoy shall move normally during sunrise to sunset hours. In very special cases where night movement is required, adequate precaution should be taken and proper illumination to be provided. Wherever the help from traffic police is required, the Package CONTRACTOR shall arrange for local police to ensure safe transport of consignment and regulation of other traffic.

Certification of transport equipment : The Package CONTRACTOR shall provide all relevant documents for the equipment being used by him to transport above consignments to ensure good health of equipment in particular, sea worthiness and validity of

equipment for redeployment. The Package CONTRACTOR shall inspect the equipment before considering the bid of party.

Lashing: The Package CONTRACTOR shall arrange for lashing materials required for consignments to ensure that they are safely & firmly secured to transport equipment and under no circumstances there is relative movement in between consignments and transporting equipment. The Package CONTRACTOR shall provide detailed sketch indicating loading arrangement and lashing arrangement of consignment on transport equipment. The lashing details shall include size and material used for lashing.

Overhanging: In no case overhanging of consignment is permitted lengthwise. Widthwise overhanging if any, proper permission shall be obtained from competent authority. Proper demarcation of overhang to be done by providing red flags/lights.

SECTION NO.	TITLE	NO. OF SHEETS
C-1-26	ERECTION AND COMMISSIONING SPECIFICATION	
C-1-26.1	SCOPE	
C-1-26.2	APPLICABLE CODES, STANDARDS AND SPECIFICATIONS	
C-1-26.3	ITEMS / SERVICES INCLUDED INSCOPE OF WORK	
C-1-26.4	ITEMS/ SERVICES NOT INCLUDED IN SCOPE OF WORK	
C-1-26.5	APPROVAL OF ERECTION, TESTING & COMMISSIONING PROCEDURES	
C-1-26.6	INSPECTION AT SITE	
C-1-26.7	CONTRACTOR's STAFF & LABOUR	
C-1-26.8	SUB-CONTRACTORS	
C-1-26.9	CO-ORDINATION WORK	
C-1-26.10	PLANNING AND PROGRESS REVIEW	
C-1-26.11	LAYOUT & MEASUREMENTS	
C-1-26.12	SANITATION	
C-1-26.13	CLEAN-UP	
C-1-26.14	SERVICES SUPPLIED BY PURCHASER	
C-1-26.15	TRANSPORTATION OF ERECTION EQUIPMENT AND MATERIAL AT SITE	
C-1-26.16	ACCESS ROADS AND TEMPORARY BUILDINGS	
C-1-26.17	ACCOMMODATION AND TRAVEL	
C-1-26.18	ACCESS TO SITE	
C-1-26.19	SEISMIC REQUIREMENTS	
C-1-26.20	SITE WELDING	

C-1-26.21 SECURITY RULES

C-1-26.22 GROUTING

C-1-26.23 NOTICES

C-1-26.24 COMMISSIONING

26.1.1.0 The scope of this specification shall be for erection, testing and commissioning and performance testing of all systems, structures & equipment and all other items supplied under this contract up to the terminal points covered under the scope of contract.

26.1.2.0 It is to be understood and agreed by CONTRACTOR, that the work described shall be complete in detail, even though every item necessarily involved is not particularly mentioned. CONTRACTOR shall be required to provide all labour, materials and equipment necessary for the completion of the entire work described and shall not avail himself of any unintentional error, omission or inconsistency that may exist.

For statutory requirement please refer General Conditions of Contract in Section-B

26.3-1.0 EQUIPMENT TO BE ERECTED, TESTED AND COMMISSIONED

26.3-1.1 All the system structure & equipment covered under scope of this package shall be erected tested and commissioned by CONTRACTOR. The CONTRACTOR shall erect, test and commission all system structures & equipment and all other items supplied by the CONTRACTOR and supplied to CONTRACTOR as free issue material by PURCHASER under this contract.

26.3-2.0 SCOPE OF SERVICES

CONTRACTOR'S scope of services shall include but not be limited to the following:

26.3-2.1 CONTRACTOR shall be responsible for transporting the equipment and materials from his SUB-CONTRACTOR's works to site, unloading from carriers at site, unpacking, inspection and inventory control including checking against invoices, re-packing where required, submitting shortages/ damages reports, equipment storage and erection insurance. Lodging insurance claims against losses/ damages, etc.

26.3-2.2 CONTRACTOR shall provide closed/semi-closed /open storage facilities and shall ensure proper storage and maintenance of plant and equipment to be erected CONTRACTOR shall indicate his space requirements for provision of closed, semi-closed and open storage areas to the PURCHASER. He should also indicate the space requirements for office, workshop, canteen etc., if any

26.3-2.3 Transportation of materials to the CONTRACTOR'S stores and transportation of the same to erection site is the responsibility of CONTRACTOR.

26.3-2.4 Transferring levels and coordinates from the master benchmarks provided by the PURCHASER will be carried out by CONTRACTOR.

26.3-2.5 Proper erection including grouting of foundation bolts, base plates etc., preparation of foundation including breaking the lean mortar cover, chipping etc., as required before placing base plate and final grouting of foundation bolts will be carried out by CONTRACTOR.

26.3-2.6 Finish painting as well as anti-corrosive painting as required for all systems , structure & components erected by CONTRACTOR including the supply of necessary paints, varnishes, primers, thinner and other painting materials of approved quality and colour as directed by PURCHASER will be the responsibility of the CONTRACTOR.

26.3-2.7 All the equipment, tools & tackles required for the erection of various systems, structure & equipment shall be arranged by the CONTRACTOR.

26.3-2.8 Supply of adequate quantity of all consumables required for the job, viz., welding electrodes, scaffolding, welding gas, oil, grease, kerosene, cotton waste, etc, shall be supplied by the CONTRACTOR.

26.3-2.9 Supply and initial filling of various lubricants and control fluids shall be arranged by the CONTRACTOR. For lubrication and control purpose if mineral oil is used for TG & Auxiliaries and any other equipment, the same shall be used from Indian Source. Acceptability of the same shall be indicated by CONTRACTOR in his bid.

26.3-2.10 The CONTRACTOR shall carryout hydro-test of all piping erected by him as directed by and to the satisfaction of the PURCHASER. All temporary piping hangers and supports, fittings, strainers, valves blanks for hydro testing of the pipelines, valves and equipment shall be supplied by the CONTRACTOR. It is the CONTRACTOR's responsibility to arrange for all pumps, tanks, instruments and other accessories that would be required for testing operations. These are to be taken back by CONTRACTOR after successful completion of all hydro-testing operations.

26.3-2.11 Arranging for statutory inspections and clearances as required shall be by the CONTRACTOR.

26.3-2.12 CONTRACTOR shall set all spring hangers and supports to the required load and record all spring settings and furnish the readings as per the prescribed format, to be finalised after award of contract, to PURCHASER for approval. A report of this shall be prepared and submitted to PURCHASER.

26.3-2.13 CONTRACTOR shall erect and test all instrument impulse piping and fittings over their entire length upto and including the instruments for all instruments in his scope of supply. For all other instruments mounted on his piping, CONTRACTOR will erect and test impulse piping and fittings upto a distance of 500 mm from the last root valve or reducer after root valve as applicable.

Valves shall be tested for seat and gland leakage prior to erection at Valve Testing Facility to be setup by CONTRACTOR as per C-2-2-8-12.

26.3-2.14 Cleaning of Piping Systems: All pipes, pipe fittings and other piping components shall be cleaned prior to erection (Refer C-2-2-8-12).

26.3-2.14.1 CONTRACTOR shall carryout following cleaning operations after erection and hydro static test.

a) All piping shall be mass flushed, in addition to specific cleaning operations as described below, as required.

b) Alkaline flushing operation shall be carried out for all piping of Turbine cycle as called for in this specification.

26.3-2.14.2 CONTRACTOR's scope of work includes erection of temporary pipework including hangers and supports. Valves and specialities and other associated equipment (viz. Pumps, blowers, tanks etc.) to be supplied by CONTRACTOR for carrying out the cleaning operations as described above.

26.3-2.14.3 After successful completion of these operations, CONTRACTOR shall dismantle all temporary pipework and structures, restore the permanent piping to their design condition and render the area free of debris and all other foreign matter.

26.3-2.14.4 For flushing all primary elements such as orifice plates, etc which can be damaged in the process of cleaning, shall be removed. Orifice plates shall be replaced by suitable dummy plates. The dummy plates will be provided by CONTRACTOR. For on-line instruments, by pass lines shall be used for flushing. The on-line instruments, which have no by pass, shall be replaced by suitable spool pieces while flushing. These spool pieces will be provided by CONTRACTOR. Like wise all safety and relief valves shall be removed and their stubs blanked.

26.3-2.15 Erection of rotating machinery

26.3-2.15.1 Erection of all rotating machinery shall be in line with supplier's erection manuals and drawings.

26.3-2.15.2 CONTRACTOR shall be completely responsible for the commissioning of all the systems, structure & equipment erected. CONTRACTOR shall also carry out all the pre-commissioning checks and tests required before commissioning the equipment. A programme for pre-commissioning tests and checklist for commissioning of equipment shall be furnished by the CONTRACTOR to PURCHASER.

26.3-2.15.3 CONTRACTOR shall satisfy himself that all initial check-up to ensure safety of equipment and personnel have been carried out.

26.3-2.16 All rotary equipment shall be tested individually for proper alignment and smooth operation with out exceeding permissible vibration and noise limits.

26.3-2.17 CONTRACTOR shall furnish all necessary erection tools, rigging, scaffolding, bending, framing, cutting, welding, stress relieving and testing equipment needed for the complete erection and testing of all piping and equipment including the services of all qualified and experienced personnel.

26.3-2.18 Supply of all grouting materials including ready mix special grouting materials is the CONTRACTOR's responsibility. Concrete/cement mortar cubes/briquettes, etc., shall be tested for their strength by the CONTRACTOR. Grouting permits will have to be cleared by the PURCHASER only, after which the CONTRACTOR shall undertake grouting work.

26.3-2.19 All auxiliary steel brackets required for locating the hangers, shall be fabricated and installed by the CONTRACTOR. Hangers for pressure parts shall be tested with torsion wrench for even load distribution.

26.3-2.20 The CONTRACTOR shall supply complete erection materials as required which shall but not be limited to the following:

a) Steel packers, shim (stainless steel, brass and steel). Special grouting materials, erection slings, special jacks levelling and measuring instruments etc.
b) Special tools and tackles

c) Special electrodes required for complete erection of equipment under CONTRACTOR's scope.

26.3-2.21 The CONTRACTOR shall arrange for necessary inspection and approval by statutory authorities.

26.3-2.22 The works such as disassembly cleaning and re-assembly of equipment, where required are in the scope of CONTRACTOR.

26.3-2.23 The CONTRACTOR shall carry out necessary repairs/modifications on erected plant / equipment which are due to the CONTRACTOR'S own defects/ faults.

26.3-2.24 The CONTRACTOR shall, at all times, keep the work place and storage areas free of loose or combustible materials and waste materials. The CONTRACTOR shall provide adequate fire fighting facilities and take necessary precautions. The CONTRACTOR shall ensure safe working practices. All scaffolding, temporary structures, safety devices etc., used by him during erection shall be duly removed by him on completion of work. The removal of debris and waste to the PURCHASER'S dumping yard shall be done on a daily basis to keep the site clean and safe, at all times. All waste/debris collected during work shall be removed promptly and site shall be handed over to the PURCHASER in a clean and tidy condition on completion of work. The security and safety are the sole responsibility of the CONTRACTOR.

26.3-2.25 The CONTRACTOR shall coordinate with the other equipment/system contractors, whenever it is necessary for CONTRACTOR to work at various terminal points covered under the contract.

26.3-2.26 CONTRACTOR shall setup field engineering unit during construction and commissioning activities at site. This unit shall resolve the day to day engineering problems faced at site during construction & commissioning. Field engineering unit shall comprise of engineers from engineering consultant of CONTRACTOR or from design & engineering department of the CONTRACTOR.

26.4-1.0 None of the items are excluded from the CONTRACTOR's scope of services under the contract.

26.5-1.0 The CONTRACTOR shall submit to the PURCHASER for his approval within a reasonable period a programme showing in such form as may reasonably be required by the PURCHASER, the order of procedure in which he proposes to carryout the works as to erection, testing and commissioning activities. The programme shall also indicate the times by which the CONTRACTOR requires the PURCHASER to have obtained any consents, approvals, etc. necessary for the purpose of the works. The submission to and approval by the PURCHASER of such programme shall not relieve the CONTRACTOR of any of his duties or responsibilities under the contract. Detailed procedure for carrying out erection, testing and commissioning, trial operation, performance testing & handing over for all systems, structures and equipment shall be submitted by CONTRACTOR for PURCHASER's approval prior to start of these activities, in a format and contents to be approved by PURCHASER.

Detailed procedure for carrying out erection, testing and commissioning, trial operation, performance testing & handing over for all systems, structures and equipment shall be submitted by CONTRACTOR for each & every individual system, structure and equipment.

26.5-2.0 After submission to and approval by the PURCHASER of such programme the CONTRACTOR shall adhere to the order of procedure and method stated therein unless he obtains the written permission of the PURCHASER to vary such method or order.

26.5-3.0 If at any time it should appear to the PURCHASER that the actual progress of the works does not conform to the programme, the CONTRACTOR shall produce, at the written request of the PURCHASER, a revised programme showing modifications to the approved programme necessary to ensure completion of the works within the time for completion.

26.5-4.0 The CONTRACTOR shall submit well in advance, his scheme for movement / lifting / handling of heavy equipment / components also indicating the tools, tackles and equipment he proposes to employ for the same, for approval by the PURCHASER prior to actual undertaking of such work. This is essential as such activities may call for measures such as additional reinforcements to avoid overloading of structures.

26.5-5.0 The CONTRACTOR shall submit a detailed write-up on performance test procedure along with sample calculations for PURCHASER's approval and the same shall be finalised prior to actual performance testing.

26.6-1.0 PURCHASER or any person appointed by them shall have access and right to inspect the work, or any part thereof, at all times and places during the progress of the work. The inspection and supervision is for the purpose of assuring PURCHASER that the plans and specifications are being properly executed and while PURCHASER or their representatives will extend to CONTRACTOR all desired assistance in interpreting the plans and specifications, such assistance shall not relieve CONTRACTOR of any responsibility for the work. Any work which proves faulty shall be corrected by CONTRACTOR without delay. The fact that the PURCHASER or their representatives have not pointed out faulty work or work which is not in accordance with the plans and specifications shall not relieve CONTRACTOR from correcting such work as directed by PURCHASER without additional compensation.

26.6-2.0 When finished work is taken down for purpose of inspection, CONTRACTOR shall stand all the expenses incident thereto in the event that the said work is found to be defective. If CONTRACTOR shall fail to repair any defective work or replace any defective materials after reasonable notice, PURCHASER may cause such defective work to be repaired or defective material to be replaced and the expenses thereof shall be deducted from the amount to be paid to CONTRACTOR.

26.6-3.0 CONTRACTOR shall give every facility to PURCHASER and his representatives for inspection, examination and workmanship even to the extent of discontinuing portions of the work temporarily, or of uncovering or taking down portions of the finished work.

For CONTRACTOR's staff & labour for site work refer clause 12 of General Conditions of Contract in Section-B.

26.8-1.0 All specialists, engineering consultants, procurement agencies, commissioning agencies, plant operating agencies, merchants, tradesmen and others executing any work or supplying any goods, materials or service appointed by the CONTRACTOR shall be deemed to be sub-contractors. Any work as given in scope of this contract which CONTRACTOR is getting done by others, these "others" shall be deemed to be sub-contractors.

26.8-2.0 The CONTRACTOR shall not sublet the whole of the work under the scope. CONTRACTOR may sub-contract parts of the order, if necessary, only to sub-contractors approved by PURCHASER. All SUB-CONTRACTORs shall be appointed only with the prior approval of PURCHASER. The experience list of sub-contractors shall be furnished to the PURCHASER for approval. Such sub-letting shall not relieve the CONTRACTOR from any obligation, duty or responsibility under the contract. CONTRACTOR shall be responsible for transmitting pertinent data of the contract terms and conditions to sub-contractors. CONTRACTOR shall also furnish to PURCHASER the required copies of all sub-contracts (unpriced) showing promised delivery dates, places, etc.

26.8-3.0 In respect of the work, goods, materials or services etc. specified in the sub-contract, the sub-contractor will undertake towards the CONTRACTOR the like obligations and liabilities as are imposed on the CONTRACTOR towards the PURCHASER by the terms of the contract and will save harmless and indemnify the CONTRACTOR from and against the same from all claims, proceedings, damages, costs, charges and expenses whatsoever arising out of or in connection therewith, or arising out or in connection with any failure to perform such obligations or to fulfil such liabilities.

26.8-4.0 The sub-contractor will save harmless and indemnify the CONTRACTOR from and against any negligence by the SUB-CONTRACTOR, his servants or agents and from and against any misuse by him or them of any CONTRACTOR's equipment provided by the CONTRACTOR for the purposes of the contract.

26.8-5.0 The PURCHASER shall be entitled to demand from the CONTRACTOR reasonable proof that all payments; less retention have been made to sub-contractor in respect of the work or goods, materials or services of subcontractor. Also the CONTRACTOR shall, if any,

a) Satisfy the PURCHASER in writing that he has reasonable cause for withholding or refusing to make such payments.

b) Produce to the PURCHASER reasonable proof that he has so informed sub sub-contractor in writing.

26.9-1.0 CO-OPERATION WITH OTHER CONTRACTORS

26.9-1.1 The CONTRACTOR shall co-operate with all other contractors or tradesmen of the PURCHASER, who may be performing other works on behalf of the PURCHASER and the workmen who may be employed by the PURCAHSER and doing the work in the vicinity of the works or at various CONTRACTOR's terminal points covered under the contract. The CONTRACTOR shall also so arrange to perform his work as to minimise, to the maximum extent possible, interference with the work of the other contractors and his workmen. Any injury or damage that may be sustained by the employees of the other contractors and the PURCHASER, due to the CONTRACTOR's work shall promptly be made good at his own expense. The PURCHASER shall determine the resolution of any difference or conflict that may arise between the CONTRACTOR and other contractors or between the CONTRACTOR and the workmen or the PURCHASER in regard to their work. If the works of the CONTRACTOR is delayed because of any acts or omission of another contractor, the CONTRACTOR shall have no claim against the PURCHASER on that account other than extension of time for completing his works.

26.9-1.2 The PURCHASER shall be notified promptly by the CONTRACTOR of any defects in the other contractors works that could affect the CONTRACTOR's works. The PURCHASER shall determine the corrective measures, if any, required to rectify this situation after inspection of the works and such decisions by the PURCHASER shall be binding on the CONTRACTOR.

26.9-2.0 CONTRACTOR'S CO-OPERATION WITH THE PURCHASER

26.9-2.1 In cases where the performance of the erection work by the CONTRACTOR affects the operation of the system facilities of the PURCHASER, such erection work of the CONTRACTOR shall be scheduled to be performed only in the manner stipulated by the PURCHASER and the same shall be acceptable at all times to the CONTRACTOR. The PURCHASER may impose such restrictions on the facilities provided to the CONTRACTOR such as electricity, water, etc. as he may think fit in the interest of the PURCHASER and the CONTRACTOR shall strictly adhere to such restrictions and co-operate with the PURCHASER. It will be the responsibility of the CONTRACTOR to provide all necessary temporary instrumentation and other measuring devices required during start up and operation of the equipment/systems, which are erected by him. The CONTRACTOR shall also be responsible for flushing and initial filling all the oils and lubricants required for the equipment furnished and erected by him, so as to make such equipment ready for operation. The CONTRACTOR shall be responsible for supplying such flushing oil and other lubricants unless otherwise specified elsewhere in these documents and specifications.

For planning and progress review refer clause 15.2 of General Conditions of Contract in Section-B

However, CONTRACTOR shall ensure the use of latest version of internationally accepted and widely used Project Management Software for planning, scheduling and monitoring of all the activities under the scope of this specification. Contractor shall regularly update the status on progress of job and furnish the required information in the mutually agreed format. CONTRACTOR shall ensure development of resource based network for level-1, level-2, level-3 and level-4 to suit purchaser's requirement.

CONTRACTOR shall comply with the requirements of real time integrated computerised progress monitoring system as per Annexure to this section, covering the total scope of work from design & Engineering up to commissioning.

Other Management Information System as sought by purchaser from time to time shall also be provided by CONTRACTOR.

26.11-1.0 All the works shall be performed to the lines, grades and elevations indicated on the drawings. CONTRACTOR shall set out the works and shall be responsible for the true and perfect setting out of the same and also for the correctness of the positions, levels, dimensions and alignment of all parts thereof.

26.11-2.0 Basic horizontal and vertical control points will be established and marked by the PURCHASER at site at suitable points. These points shall be used as datum for the works under the contract.

26.11-3.0 The CONTRACTOR shall inform the PURCHASER well in advance of the times and places at which he wishes to do work in the area allotted to him, so that suitable datum points may be established and checked by PURCHASER to enable the CONTRACTOR to proceed with his works.

26.11-4.0 If at any time any error shall appear during the progress of any part of the work, CONTRACTOR shall, at his own expense, rectify such error, if called upon to do so, to the satisfaction of PURCHASER.

26.11-5.0 CONTRACTOR shall maintain base lines and bench marks adjacent to various sections of work. In case of their unnecessary destruction by him or any of his employees, these shall be re-established by CONTRACTOR at his own expense.

26.11-6.0 The CONTRACTOR shall level and adjust the plant on its foundations preparatory to grouting and shall furnish all packings and shims required for the adjustment.

26.11-7.0 The CONTRACTOR shall check the electrical and mechanical connections to plant supplied under the contract before such plant is commissioned and shall be responsible for the correctness of such connections in accordance with the contract drawings and specifications.

26.11-8.0 MEASUREMENT OF WORK

26.11-8.1 PURCHASER may, from time to time, intimate CONTRACTOR that he requires the works to be measured and CONTRACTOR shall attend or send a quality agent to assist PURCHASER or his representative in taking such measurements and calculations and to furnish all particulars as may be required by him.

26.11-8.2 Where the erection of equipment, vessels and structural steel are involved, the basis of such measurements and progress evaluation shall be weights specified in the shipping documents or invoices or drawings as decided by PURCHASER.

26.11-8.3 Should CONTRACTOR not attend or neglect or omit to send such agents, then, the measurement taken by PURCHASER shall be taken to be the correct measurements of the work.

26.11-8.4 CONTRACTOR or his agent, may at the time of measurement, take such notes of measurements as he may require.

26.11-8.5 When measurements are affected by conditions already established, CONTRACTOR shall take field measurements notwithstanding scale or dimensions shown on the drawings.

26.11-8.6 The measurements so taken and certified correct by PURCHASER shall be the basis for the progress payment to the CONTRACTOR. Where the break up of contract value on unit basis is difficult to arrive at PURCHASER and CONTRACTOR shall work out at the commencement of the CONTRACT, the weightages or the cost of breakups to the arrive at a mutually agreeable basis for computation of this progress estimates.

26.11-8.7 As per clause 5.9.7 of General Conditions of Contract, regarding the terms of payment for erection and commissioning, a portion of the payment will be given on pro-rata basis against satisfactory completion of identified milestone. The contractor shall note that satisfactory completion of milestone means erection and commissioning of sub systems of TG and secondary cycle systems. No pro-rata payment will be made against erection and commissioning of sub systems of TG and secondary cycle systems if such systems are incomplete w.r.t. systems, structures and components.

CONTRACTOR shall keep the labour colony, the offices and residential areas of their employees and workmen clean and neat to the entire satisfaction of the PURCHASER. Proper sanitary arrangements shall be provided by the CONTRACTOR, in the work-areas, offices and residential areas of the CONTRACTOR.

26.13-1.0 The CONTRACTOR shall be responsible for keeping the entire area allotted to him clean and free from rubbish, debris, etc., during the period of contract. The CONTRACTOR shall employ enough number of special personnel to thoroughly clean his work as and when required. All such rubbish and scrap material shall be stacked or disposed of in a place to be identified by the PURCHASER. Materials and stores shall be so arranged as to permit easy cleaning of the area. In areas where equipment might drip oil and cause damage to the floor surface, a suitable protective cover of a flame resistance, oil proof sheet shall be provided to protect the floor from such damage.

26.13-2.0 All soil, filth or other matter of an offensive nature taken out of any trench, sewer, drain, cesspool or other place shall not be deposited on the surface, but shall at once be carried away by CONTRACTOR, from the site of work for suitable and proper disposal.

26.13-3.0 CONTRACTOR shall not store or place the equipment, materials or erection equipment on the driveways and streets and shall take care that his work in no way restricts or impedes traffic or passage of men and material. During erection, CONTRACTOR shall, without any additional payment, at all times keep the working and storage areas used by him free from accumulation of loose, combustible material, waste materials, rubbish, to avoid fire hazard and hindrance to other works of PURCHASER. If CONTRACTOR fails to comply with these requirements in spite of written instructions, PURCHASER will proceed to clear those areas and the expenses incurred by PURCHASER in this regard shall be payable by CONTRACTOR. Before completion of the work, CONTRACTOR shall remove or dispose of in a satisfactory manner all scaffolding, temporary structure, waste and debris and leave the premises in a condition satisfactory to PURCHASER. Any packing materials received with the equipment shall remain the property of PURCHASER and may be used by CONTRACTOR for the performance of the work on payment of standard charges to PURCHASER and with prior approval of PURCHASER. Or otherwise, packing materials shall be kept in the area identified by the PURCHASER. At the completion of his work and before final payment, CONTRACTOR shall remove from site all construction equipment, temporary structures and debris and shall restore the site to neat workmanlike conditions, at his cost.

26.14-1.0 SITE FACILITIES

The details of the various site facilities as may be required for execution of work under this contract, their availability and relevant terms and conditions where applicable are as follows :

26.14-1.1 The following facilities will be provided by the PURCHASER in good faith at terms indicated hereunder :

(a) For details regarding Electricity supply, refer Clause No.11.5 of General Conditions of Contract in Section-B.

(b) Open space for construction of necessary stores will be provided by the PURCHASER. Whereas space will be provided by the PURCHASER at charges (if any) to be indicated later, the building of necessary stores, their safety and security as well as subsequent removal of the same on completion of work under the Contract are the responsibility of the CONTRACTOR. The CONTRACTOR shall indicate the extent of storage space required for various types of stage, viz., open, paved closed, semiclosed and air-conditioned.

(c) The PURCHASER will allot only space, at charges (if any), to the CONTRACTOR for construction of his temporary structures like office, storage sheds and other utilities, etc. for his own as well as his SUB-CONTRACTOR's use. The CONTRACTOR shall construct the temporary structures on his own. The space will be allotted within a reasonable distance from the site. The CONTRACTOR shall make proper sanitary arrangements in the work areas and site office and labour colony as per the requirements of local bodies and statutory authorities.

(d) No claim, whatsoever, arising out of use, misuse or failure of these facilities will be entertained by the PURCHASER.

26.14-2.0 The PURCHASER will not be able to provide the following facilities and it is the responsibility of the CONTRACTOR to make suitable arrangements for the same.

a) Water

For details regarding water supply provision, refer clause 11.5 of GCC, Section B

(b) Compressed Air

The CONTRACTOR should provide his own portable compressors, temporary piping and accessories.

(c) Workshop Facilities

The CONTRACTOR should arrange to set up his own workshop to carry out site fabrication as may be required.

(d) Canteen Facilities

The CONTRACTOR shall arrange canteen facilities to cater to the requirements of his personnel.

26.15-1.0 SCOPE

This following specification details the general guidelines for the CONTRACTOR as regards receipt, unloading and transport to warehouses of equipment covered under this contract. At all times, the instructions of the PURCHASER shall be strictly adhered to.

26.15-2.0 RECEIPT

26.15-2.1 The Equipment may be despatched by the CONTRACTOR to Site by suitable carriers by road, rail or sea as applicable and in some cases even by air. The CONTRACTOR shall promptly unload the Equipment covered under this contract from such carriers at the point of unloading as directed by the PURCHASER with care and in the manner prescribed.

26.15-2.2 Any demurrage incurred due to delays in unloading from carriers shall be paid by the CONTRACTOR.

26.15-2.3 It will be necessary for the CONTRACTOR to constantly keep in touch with various agencies to obtain the likely time of arrival of consignment so that necessary planning for unloading of equipment can be made.

26.15-2.4 It is the responsibility of the CONTRACTOR to ensure that he has in possession all the necessary documents such as invoices and Railway Receipts to take delivery of Equipment.

26.15-2.5 It shall be ensured that necessary insurance formalities have been fully complied with in advance. The nature and quantum of insurance to be arranged for by the CONTRACTOR is detailed elsewhere and the CONTRACTOR shall furnish satisfactory proof to the PURCHASER that necessary insurance coverage as required of him has been provided.

26.15-2.6 Time of placing of wagons at unloading yard as well as time allowed for clearing the wagons are to be checked with Railways to ensure that no demurrage is incurred. The procedures to be followed in case of loss / damage are to be finalised with Railways before hand.

26.15-2.7 For heavy / sophisticated equipment, detailed scheme for unloading from carriers should be finalised well in advance in consultation with the PURCHASER so that necessary tools and tackles can be tested and kept ready for prompt unloading. The contractor shall take note of layout, specially the hot spots for handling the major equipment and make suitable handling arrangement. It will be necessary for the CONTRACTOR to scrutinise the invoices, Railway receipts and other available documents to study the sizes and weights of consignment and arrange for suitable handling equipment to meet the requirement.

The CONTRACTOR shall submit to the PURCHASER or CONSULTANT a list of equipment he proposes to use indicating their capacities and quantities as well as the scheme of handling for approval by the PURCHASER or CONSULTANT.

The various lifting / handling equipment and rigging tools proposed to be used by the CONTRACTOR shall be tested as per statutory and safety regulations and the latest test certificates shall be furnished to the satisfaction of the PURCHASER. In case the PURCHASER feels that the tools and tackles are inadequate or unsuitable, the CONTRACTOR shall arrange to provide such tools and tackles considered suitable by the PURCHASER in sufficient quantities acceptable to the PURCHASER.

26.15-3.0 **UNLOADING**

26.15-3.1 The equipment on arrival at site shall be inspected on the carrier itself. In case of closed wagons, the condition of the seals shall be checked to detect any possible tampering.

26.15-3.2 The goods should be unloaded and compared with Railway Receipts (RR) and in case any shortages / damage are noticed, the same shall be promptly notified to Railway authorities / transport agency and the PURCHASER. Whenever damage is noticed, it will be necessary to inform the insurance company and arrange inspection by their representatives to assess the extent of damage.

26.15-3.3 When the equipment is to be unloaded from the railway wagons, if any damage to the consignment is notified, and an 'open delivery' taken, it should be decided in consultation with the Railways whether the consignment should be kept at the Railway siding itself until Railways issue 'open delivery certificate' or whether it can be moved to storage shed.

26.15-3.4 Wherever feasible, the equipment should be directly loaded on a lorry or tractor-trailer. Otherwise, packages shall be unloaded on sleepers or concreted plinths and transported to stores as easily as possible.

26.15-3.5 In case mode of transport is by truck, the consignment should be taken as near to the storage shed as possible to avoid double handling.

26.15-3.6 In case mode of transport is by sea, besides bill of lading / invoices, it will be necessary to keep instruction manuals and drawings ready to enable easy identification of the equipment to customs authorities.

In case of short shipment, ship survey by competent agency should be carried out and result of such survey promptly notified to the insurance company.

In case of damage, an endorsement to this effect should be obtained from competent dock authorities on the invoice, so those insurance claims can be easily processed.

26.15-3.7 Unloading of equipment shall be carried out by competent experienced personnel using suitable handling equipment and proper safe procedures.

26.15-3.8 The CONTRACTOR shall submit to the PURCHASER copies of inspection reports as well as overages / shortages / damages (OSD) reports within a specified period from date of receipt of equipment at site. The CONTRACTOR shall take up with the transport agency and insurance companies. If so desired by the PURCHASER, such inspection shall be carried out in the presence of the PURCHASER. The CONTRACTOR shall lodge all insurance claims.

26.15-3.9 The CONTRACTOR will be responsible for any damage caused due to his defective / negligent handling of equipment and he shall make good such damages at no extra cost to the PURCHASER and without affecting the project schedule. Any repairs carried out shall be with the prior written approval from the PURCHASER and under CONTRACTOR supervision. A complete record of all such repair works shall be maintained by the CONTRACTOR at all times.

26.15-4.0 TRANSPORT TO WAREHOUSES

26.15-4.1 To the extent feasible, all equipment / materials shall be transported from unloading point to the warehouses immediately after unloading from the carriers. In case equipments are despatched by road carriers, it is preferable to unload them directly in the warehouse or very near to the warehouse.

26.15-4.2 Transport of equipment by dragging, pulling, skidding on rollers etc., will require the prior written approval from the PURCHASER and are generally discouraged. In all cases where major components have to be handled, the detailed scheme shall be submitted to the PURCHASER for prior approval.

26.15-4.3 It is the responsibility of the CONTRACTOR to provide adequate weather protection and security for the equipment during the period they are transported from the unloading point to warehouses. The safe loading of equipment as well as transport up to warehouses shall be closely supervised by the CONTRACTOR.

26.15-4.4 The CONTRACTOR shall, on receipt of equipment at the warehouse, arrange for unloading the same from the carriers and storing them in the warehouses as directed by the PURCHASER.

26.15-5.0 INSPECTION

26.15-5.1 The equipment on arrival at warehouse shall be inspected and OSD report shall be submitted to the PURCHASER within a week from date of receipt of consignment or as specified.

26.15-5.2 The CONTRACTOR shall promptly advise the PURCHASER the damage if any noticed during inspection. The equipment certified as satisfactory shall be taken into warehouses and in case of equipment damaged, the equipment shall be replaced at the cost of CONTRACTOR

26.15-5.3 It is the responsibility of the CONTRACTOR to submit periodical reports on the equipment received during the period of reporting as well as those scheduled to be received but not yet received to enable the PURCHASER to take necessary action in time. The proper mode of storage is detailed in this Section.

26.15-6.0 LABOUR AND SUPERVISION

26.15-6.1 The CONTRACTOR shall employ adequate number of competent personnel for work under this Contract and ensure that adequate handling aids / equipments are made available in time and safe working methods are adopted at all times and all relevant statutory regulations are strictly adhered to.

26.15-6.2 The CONTRACTOR shall indemnify the PURCHASER against all claims which may be made under the "Workmens Compensation Act" and other statutory rules and regulations or in respect of any damages / compensation payable consequent to any accident or injury caused by the CONTRACTOR / his sub CONTRACTOR.

26.15-7.0 STORAGE OF MECHANICAL AND ELECTRICAL EQUIPMENT AT SITE

26.15-7.1 Scope

The following specification details the general guidelines for storage of mechanical and electrical equipment at site from the date of receipt of equipment at site by the CONTRACTOR till the same are erected and handed over to the PURCHASER.

26.15-7.2 Storage Classification

The types of storage are broadly classified under the following heads :

1 Special storage – Air conditioned
2 Closed storage
3 Semi closed storage
4 Open storage

The equipment covered under these specifications shall be stored in the type of storage as recommended by the MANUFACTURER / PURCHASER.

26.15-7.3 **Construction of Stores**

26.15-7.3.1 Normally, the PURCHASER makes available the space (at terms specified) for the CONTRACTOR to construct the necessary stores as specified.

26.15-7.3.2 The storage areas should have adequate unloading and handling facilities with adequate passage space for movement of material handling equipment such as cranes forklift trucks etc. The storage of materials shall be properly planned to minimise wasteful handling during retrieval of items required for erection.

26.15-7.3.3 The outdoor storage areas as well as semi closed stores shall be provided with adequate drainage facilities to prevent water logging. The CONTRACTOR shall check the satisfactoriness of these facilities prior to monsoon.

26.15-7.3.4 The storage sheds shall be built in conformity with fire safety requirements. The stores shall be provided with adequate lights and fire extinguishers. "No smoking' signs shall be placed at strategic locations. Safety precautions shall be strictly enforced.

26.15-7.3.5 In case of storage of certain equipment / materials, it may be necessary to maintain specified temperature ranges. In such case, it is the responsibility of the CONTRACTOR to provide adequate heating / air conditioning facilities on round the clock basis. The CONTRACTOR shall check that space heaters, heating bulbs and air conditioners are kept energised continuously as applicable. In the event there is a prolonged failure of electric power, rendering such air conditioners / space heaters inoperative, the CONTRACTOR shall make alternative arrangements to ensure that items under storage do not suffer any damage / deterioration on this account.

26.15-7.3.6 Adequate lighting facility shall be provided by the CONTRACTOR in storage areas and storage sheds and security personnel positioned to ensure enforcement of security measures to prevent theft and loss of materials. The CONTRACTOR shall carryout regular inventory of materials received, issued and erected and inform the PURCHASER of any loss when noticed.

26.15-7.3.7 The CONTRACTOR shall provide adequate number of competent stores personnel including store keepers, clerical staff, inspection engineers, watchmen and security staff to efficiently store and maintain the equipment / material.

26.15-7.3.8 Where necessary, the CONTRACTOR shall provide necessary space heating and other protective care to equipment in case it will take a long time to haul them to the stores. Any equipment, left in the open under such conditions shall be, if required, covered with tarpaulin.

26.15-7.4.0 **MAINTENANCE DURING STORAGE**

26.15-7.4.1 The CONTRACTOR is responsible for maintenance of the equipment / materials in storage, during erection and until commissioning including protection of the same against theft, elements of nature and corrosion damages. In case commissioning of the equipment is delayed, the CONTRACTOR shall be responsible for maintenance of the erected plant and equipment as directed by the PURCHASER or as per the instructions from manufacturer.

26.15-7.4.2 The CONTRACTOR shall repack the equipment after inspection and store the same in an orderly manner, preserving their identification slips, tags and instruction booklets, etc., required during erection. The storage of materials shall be equipment wise. Loose parts shall be stored in sheds on racks, preserving the identification marks and tags in good condition. The group codes shall be displayed on the racks.

26.15-7.4.3 The CONTRACTOR shall carryout frequent inspection of materials stored and also extend necessary facilities to the PURCHASER to carryout such inspection, when considered necessary. The CONTRACTOR shall implement the suggestions, if any, of the PURCHASER in this connection.

26.15-7.4.4 At no time shall any material be stored directly on ground. All materials shall be stored minimum 200 mm above the ground by providing good wooden sleepers.

26.15-7.4.5 Welded and cast units shall be stored in such manner that there is no danger of distortion.

26.15-7.4.6 All special measures to prevent corrosion shall be taken by the CONTRACTOR.

26.15-7.4.6.1 Materials, which carry a protective coating, shall not be wrapped in paper, cloths etc, as these are liable to absorb and retain moisture. The CONTRACTOR shall inspect the materials and in case of signs of wear or damages to protective coating, that portion shall be cleaned with appropriate solution and coated with an appropriate compatible protective paint. Complete record of all such observations and protective measures taken shall be maintained.

26.15-7.4.6.2 The rust preventive oil or grease for application on machined / fabricated components shall be adequate for the intended purpose and shall not cause any injury to the system, structure and components.

26.15-7.4.6.3 Protective coatings/application of grease, oil etc shall be inspected from time to time and reapplication/ repair shall taken at appropriate frequency.

26.15-7.4.7 While handling the equipment, no dragging on the ground is permitted. The CONTRACTOR shall submit his scheme for handling major pieces of equipment for approval by the PURCHASER prior to actual handling of the same. In cases where a scheme is recommended by the MANUFACTURER, it shall be strictly adhered to.

26.15-7.4.8 The CONTRACTOR shall periodically inspect materials with specific reference to.

33.15-7.4.8.1 Ingress of moistures and corrosion damages.

Regular inspection and renovation of silica gel is essential.

26.15-7.4.8.2 Damage to protective coating.

26.15-7.4.8.3 Open ends in pipes, vessels and equipment.

In case any open ends are noticed, the CONTRACTOR shall get them capped.

26.15-7.4.8.4 Insulation of electrical equipment.

Regular insulation checks are essential and these values shall be properly logged.

26.15-7.4.8.5 Any damages to equipment / materials.

In case of any damages, these shall be promptly notified to the PURCHASER. In all cases, the repairs / rectification shall be carried out strictly as directed by the PURCHASER.

In such repairs rectification is necessitated due to causes attributable to the CONTRACTOR, such repairs / rectification shall be carried out at no extra cost to the PURCHASER.

In case such damages are attributable to the CONTRACTOR and if, in the opinion of the PURCHASER, the CONTRACTOR is not competent to carry out necessary repairs / rectification, the PURCHASER shall get this done by any other agency and recover the expenditure incurred by him from the CONTRACTOR.

26.15-7.5 **Modes of Storage**

Given below are the general guidelines for storage of various equipment under the broad storage classification listed in clause 7.2 above. Wherever the specific recommendations of the MANUFACTURER / PURCHASER are at variance with what is indicated below, the former shall prevail.

26.15-7.5.1 Special Storage – Air Conditioned :

The following materials are normally stored in air-conditioned storage.

26.15-7.5.1.1 Welding Electrodes

These deteriorate under adverse conditions of storage and are preferably stored in air-conditioned storage. As an alternative, if approved, these can also be stored in hot boxes / ovens.

It is essential to regularly inspect the condition of electrodes and ensure that temperature is maintained within specified range at all times.

26.15-7.5.1.2 Ball, needle and roller bearings :

These shall be stored in their original packing.

26.15-7.5.1.3 Photographic materials and films.

These shall be stored in their original moisture vapour proof packages.

26.15-7.5.1.4 Rubber Goods :

These shall be protected against sunlight and artificial light as well as high humidity conditions.

26.15-7.5.1.5 Electronic Instruments and Components. These shall be stored in sealed packages.

26.15-7.5.2 Closed Storage

The following materials are normally stored in closed storage.

26.15-7.5.2.1 Cement bags.

26.15-7.5.2.2 All small parts / components liable to be misplaced / lost. These shall include the following :

a) Small structural cleats, bolts, nuts, washers etc.

High tensile bolts and nuts shall be stored in separate sealed boxes with proper identification to avoid mix up with other items.

b) Pipe hangers, spring hangers etc.

The identification numbers on spring hangers shall be carefully preserved during storage.

c) Stainless steel and copper tubes, pipe fittings, etc.

d) Electrical clamps, cable boxes, cable glands, ferrules, fuses, control cables, copper cable and grounding strips, push button switches etc.

e) Pilot valves, pull rods, keys, control valves. These shall be greased, wrapped in paraffin paper and stored in packing boxes.

26.15-7.5.2.3 All loose parts, packing plates, bolts and studs.

26.15-7.5.2.4 All indoor switchgear equipment.

26.15-7.5.2.5 All instrument parts such as measuring instruments, controllers and regulators, interlock system, control drive units, gauges, instrument valves, thermocouples and leads.

26.15-7.5.2.6 Synthetic Paints. Normally in separate stores.

26.15-7.5.3 Semi-closed Storage:

The following materials are normally stored in semiclosed storage.

26.15-7.5.3.1 Large C.I. valves, butterfly valves, stop and control valves, expansion joints.

26.15-7.5.3.2 Outdoor switchgear and panels , small transformers, cable tray parts, etc.

26.15-7.5.4 Open Storage

The following materials are normally stored in open storage.

26.15-7.5.4.1 Fabricated and unfabricated structural steel members.

Stairways and hand rails
Gallery steel
Steel members
Reinforcement steel

26.15-7.5.4.2 Coarse aggregate and sand.

26.15-7.5.4.3 Unfabricated pipes and fabricated pipe assemblies.

Large diameter conduits / pipes in boxes.

26.15-7.5.4.4 Cable drums

26.15-7.6 **Specific Guidelines for Storage**

Given below are guidelines for certain other major equipment / materials. These are broad guidelines only and storage shall be strictly as directed by the MANUFACTURER / PURCHASER.

26.15-7.6.1 **Rotating equipment such as pumps and compressors**

These are normally stored in assembled condition in closed / semi closed storage. When stored in semi-closed storage, they shall be covered with tarpaulin and bedplates shall rest fully on sleepers.

The CONTRACTOR is responsible for proper lubrication of these equipments as directed.

The gearboxes and oil sumps shall be kept filled with recommended lubricating gear oil. The couplings and bearings shall be covered with approved grease and nozzle flanges screwed with caps or suitably plugged.

The shaft and internals shall be, if so directed, given a fresh coat of approved protective paint.

Pump, if delivered in disassembled condition, shall be stored with the parts properly greased on wrapped in paraffin paper. Smaller parts are to be stored on racks whereas larger parts on sleepers in closed storage. Occasional flushing with hot lubricating oil may have to be carried out, if so directed by PURCHASER.

The shafts of rotating equipment shall be turned by 90^0 every week to avoid rotor journals from rusting and to ensure that shaft is free to rotate.

The CONTRACTOR shall maintain record of lubrication with details of lubricants used as well as protective measures carried out.

26.15-7.6.2 Piping and Valves

All pipes shall be stored on sleeper beds with open ends securely capped. The bevelled ends shall be protected with a coating of approved greases. If so directed, inside surfaces of piping shall be coated with approved protective solution.

Pipes shall be neatly arranged and stacked for easy identification and retrieval.

Pipes shall be blown with air prior to installation and it shall be ensured that there is no obstruction.

Valves shall be stored with the discs screwed down on the seat so that packing surfaces are not exposed to dust. All machined surfaces shall be covered with grease. Preservation of identification tags is essential to avoid installation in wrong services. Smaller valves shall be stored in closed storage whereas large CI valves may be stored in semiclosed storage.

Pipe fittings shall be stored on racks in closed storage in packed condition, with openings suitably capped.

26.15-7.6.3 Switchgear & Control Panels

Depending on whether these are of indoor or outdoor design, these shall be stored in closed / semiclosed storage.

The space heaters where provided, shall be kept connected with power supply irrespective of mode of storage. Where space heaters are not provided, use of adequate number of heating bulbs is recommended.

Insulation resistance shall be measured at regular intervals and megger values properly logged.

26.15-7.6.4 Transformers

It is advisable to assemble and set the transformer filled with oil in its permanent location soon after receipt even if it is not likely to be put in service for a while. In case of gas filled transformers, a positive pressure should be maintained during storage as recommended by the MANUFACTURER. If transformer is to be stored partially or fully disassembled, it shall be protected against moisture ingress / absorption by keeping them immersed in transformer oil or as recommended by the MANUFACTURER / PURCHASER.

Prior to charging any transformer, it is essential to check the satisfactoriness of insulation values and dielectric strength of oil.

26.15-7.6.5 Cells, Accumulators, Batteries

These shall be stored in a dry and well ventilated place and protected from extreme cold. Internal parts of large cells are loose and the cells should be handled with care to avoid displacement of internals. Saw dust shall never be used for packing batteries, as it is hygroscopic.

In case batteries are not put into service soon after installation, freshening charge at specified intervals will have to be resorted to.

26.15-7.6.6. Cables

Cable drums if stored indoors shall be in dry ventilated stores. Cables are normally supplied with ends sealed. When a length is cut, the end should be resealed. The drums shall be stored with adequate spacing between them for better air circulation.

26.15-7.6.7 Motors

Besides general procedures such as regular inspection and recording of insulation resistances, in the case of L.T motors, if so recommended, low voltage current flow through the windings may be maintained during storage.

26.15-7.6.8 Instruments

These are stored on racks in closed storage and in air-conditioned storage if so recommended. These shall be stored in their packages in dry condition and shall be handled with extreme care.

Instrument flanges and nozzles, if directed, shall be coated with technical Vaseline.

In the case of fragile instruments, the storage shall be in a separate zone away from where heavy materials are stored to minimise danger of damage.

26.15-7.6.9 Steel

26.15-7.6.9.1 Structural Steel

Structural steel could safely be stored in open storage but with sufficient space in between for handling and crane movement. All steel shall be stored 300 mm above ground on suitable packing to avoid damage. It should be stored according to sizes and sections preferably in the order required for erection. The area for open storage should be properly graded to avoid water logging in the storage area. Steel shall not be stored in the vicinity of areas where excavation or grading will be done. Scratched or abraded steel shall be given a coat of primer for protection after unloading and handling prior to erection. All milled and machined surfaces shall be properly protected from rust / corrosion by suitable coating.

26.15-7.6.10 Cement

Cement shall be stored in bags in a separate shed away from where mechanical and electrical equipment are stored to minimise the possibility of cement dust settling on the equipment.

The storage shed where cement is stored shall be absolutely watertight. The flooring shall be 15-mm thick concrete slab laid on a dry course soling or as recommended. The ground shall be drained away from the shed to prevent accumulation of water in its vicinity.

The bags shall be neatly stacked with adequate passage in between for easy retrieval. The cement shall be issued on 'First in-first out" basis.

In case different grades of cement are stored in the same shed, each grade shall be stacked separately to avoid mix up and clear indication boards shall be provided to identify different grades.

26.15-7.6.11 Synthetic Paints

These have limited life and as a safeguard against possible deterioration, the drums shall be inverted at regular intervals as specified to minimise risk of hard settling of pigments.

26.15-7.6.12 Slings & Wire Ropes

All slings and wire ropes shall be coated with approved grease and hung from racks in rolled condition.

26.15-7.7 **Documentation**

The CONTRACTOR'S store–keeping function will include maintaining various records as required by the PURCHASER. These records shall include but not be limited to the following.

26.15-7.7.1 Supplier wise record of equipment / material received, stored and issued for erection as well as stock position.

26.15-7.7.2 Record of inspection and repairs carried out, protective measure and lubrication of equipment in storage as well as erected until the same is taken over by the PURCHASER.

26.16-1.0 The CONTRACTOR shall make the necessary temporary access roads, footways, guards as may be necessary by reason of his work, for the protection and accommodation of foot passengers or other traffic of the site personnel/ PURCHASER's personnel. CONTRACTOR shall at all times provide sufficient temporary barriers, notice boards and lights to protect and warn the public and post necessary watchman to guard the site and equipment. He shall take all precautions necessary and shall be responsible for the safety of the work to be performed by him. CONTRACTOR shall observe and display 'SAFETY FIRST' signs and shall have proper safety and fire protection equipment.

26.16-2.0 CONTRACTOR shall construct necessary temporary buildings viz., warehouses, tool sheds, fabrication shops, enclosures, etc. for storing his equipment, tools and tackles, etc. at the site and at the place allotted by the PURCHASER.

The responsibility and cost of erecting such buildings shall be borne by the CONTRACTOR including the cost of removing such structure after the completion of the work. The CONTRACTOR shall obtain the Purchaser's approval prior to their removal in the event the PURCHASER may wish to retain any for his own purpose.

26.16-3.0 Adequate lighting such as flood lights, hand lights and area lighting and near all the storages, handling, fabrication, pre-assembly at erection sites for properly carrying out the work and for safety and security shall be provided by the CONTRACTOR at his own cost. His work area shall be adequately lighted during night time also. In any case, CONTRACTOR shall be liable for all damages and consequence arising out of his negligence in this regard. The CONTRACTOR shall obtain approval of the PURCHASER to lighting scheme prior to its installation.

26.17-1.0 ACCOMMODATION

26.17-1.1 Temporary lodging facilities including all sanitary, electric power, water and ventilation requirements for all skilled and unskilled labour, technicians, watchmen, clerical staff, etc. shall be the responsibility of CONTRACTOR. Space will not be provided by PURCHASER, for building temporary structures to accommodate CONTRACTOR's / SUB-CONTRACTOR labour.

26.17-2.0 TRAVEL

26.17-2.1 All the charges relating to the travel of CONTRACTOR'S / SUB-CONTRACTOR's personnel, labour, etc. shall be borne by the CONTRACTOR. Also the incidental charges incurred thereon shall be paid by the CONTRACTOR.

26.17-2.2 CONTRACTOR shall arrange his own mode of transport at site for all his / sub-contractor's staff, personnel, labour, etc.

26.18-2.0 In the execution of the works, no persons other than the CONTRACTOR or his duly appointed representative, SUB- CONTRACTOR and workmen, shall be allowed to do work on the site, except by special permission, in writing of the PURCHASER or his representative.

26.19-1.0 The site lies in Zone-III, as per the zoning map of India [IS-1893-2002, Part-1].

The Seismic design and qualifications for all system structures and equipment under the CONTRACTOR's scope shall be carried out by the CONTRACTOR as called for in other sections of this specification. The foundation of equipment located inside turbine building shall be designed considering acceleration values as per IS 1893.

For the seismically qualified system structures and equipment located outside turbine building within the scope of contractor, seismic design and functional qualification shall be carried out as per the respective specifications considering the response spectra for OBE and SSE. These response spectra will be furnished to successful bidder.

26.20-1.0 SITE WELDING

26.20-1.1 All site welding involved in the construction and fabrication of plant and items covered under the contract shall be carried out in accordance with applicable codes and approved procedure

26.20-1.2 All welding at site shall be carried out as specified in the respective specifications for plant and items covered in this specification as per welding procedures and welding consumables approved by the PURCHASER.

26.20-1.3 Successful TENDERER after award of contract shall furnish to PURCHASER necessary drawings indicating the extent of site assembly and welding involved.

26.21-1.0 WORK AND SAFETY REGULATIONS

26.21-1.1 The CONTRACTOR shall ensure the safety of all the workmen, materials and equipment either belonging to him or to others working at site. CONTRACTOR shall appoint a full time safety officer for this contract. CONTRACTOR shall meet all the requirement of AERB safety guide AERB-IS-1.

26.21-1.2 The CONTRACTOR will notify the PURCHASER of his intention to bring on to site and equipment or any container with liquid or gaseous fuel or other substance, which may create hazard. The PURCHASER shall have the right to prescribe the conditions under which the equipment or container may be handled and used during the performance of the Works and the CONTRACTOR shall strictly adhere to such instructions. The PURCHASER shall have the right to inspect any construction plant and to forbid its use, if in his opinion it is unsafe. No claim due to such prohibition shall be entertained by the PURCHASER.

26.21-1.3 Where it is necessary to provide and/or store petroleum products or petroleum mixtures and explosives, the CONTRACTOR shall be responsible for carrying out such provision and/or storage in accordance with the value and regulations laid down in Petroleum Act, 1934, Explosives Act 1948, & any revisions of these acts and petroleum and Carbide of Calcium Manual published by the Chief Inspector of Explosives of India. All such storage shall have prior approvals of the PURCHASER. In case, any approvals are necessary from the Chief Inspector of explosives or any statutory authorities, the CONTRACTOR shall be responsible for obtaining the same.

26.21-1.4 The CONTRACTOR shall be responsible for provision of all safety notices and safety equipment required both by the relevant legislations and the PURCHASER, as he may deem necessary.

26.21-1.5 The CONTRACTOR shall be responsible for the safe storage of his and his SUB-CONTRACTOR's radioactive sources, if any.

26.21-2.0 ELECTRICAL SAFETY REGULATIONS

26.21-2.1 In no circumstances will the CONTRACTOR interfere with fuses and electrical equipment belonging to the PURCHASER or other CONTRACTORS.

26.21-2.2 Before the CONTRACTOR connects any electrical appliances to any plug or socket belonging to the other Contractor or PURCHASER, he shall :

(a) Satisfy the PURCHASER that the appliance is in good working condition.

(b) Inform the PURCHASER of the maximum current rating, voltage and phases of the appliances

(c) Obtain the permission of the PURCHASER detailing the sockets to which the appliances may be connected.

26.21-2.3 The PURCHASER will not grant permission to connect until he is satisfied that :-

(a) The appliances are in good condition and are fitted with a suitable plug.

(b) The appliance is fitted with a suitable cable having two earth conductors, one of, which shall be an earthed metal sheathed surrounding the cover.

26.21-2.4 No electrical cable in use by the CONTRACTOR/PURCHASER will be disturbed without prior permission. No weight of any description will be imposed on any such cable and no ladder or similar equipment will rest against or be attached to it.

26.21-2.5 No work shall be carried out on any line equipment. The PURCHASER must make the equipment safe and permit-to-work issued before any work is carried out.

26.21-2.6 The CONTRACTOR shall employ the necessary number of qualified, full time electricians to maintain his temporary electrical installation.

26.22-1.0 **SCOPE**

26.22-1.1 GROUTING UNDER BASES

26.22-1.1.1 Grout shall be used under bases to ensure complete filling of the space between base plate and concrete supporting the bases.

26.22-1.1.2 Surface to be grouted shall be thoroughly roughened and cleared of all foreign matter and laitance. The concrete surfaces to be grouted shall be saturated with water. No free water shall be left on the surfaces.

26.22-1.1.3 Anchor bolts, anchor bolts holes and the bottom of column / other base plates shall be cleared of all oil, grease, dirt and loose material, or any materials, which will react with Portland cement. The use of hot, strong caustic solution for this purpose will be permitted. Water in anchor bolt holes shall be removed before grouting is started.

26.22-1.1.4 When the base is to be flow grouted, forms shall be built and securely anchored outside the base plate so as to completely confine and withstand the pressure of liquid grout under working and rodding conditions without leaking and high enough to ensure the grout is in contact with the underside of the base plate, provide a head of minimum 100 mm above the underside of the base plate. Provisions of grout holes in base plate, rodding arrangements shall be checked prior to commencement of grouting.

26.22-1.1.5 Grouting once started shall be done quickly and continuously to prevent segregation, bleeding and break down of initial set. Grout shall be worked from one end to the other to prevent entrapment of air. To distribute the grout and to ensure complete contact between base plate and foundation and to help release entrapped air, link chains, or doubled over flexible steel strapplings can be used to work the grout in place.

26.22-1.1.6 Forms and shims shall not be removed and the anchor bolts shall not be tightened for at least twenty four hours after placing the grout. After the removal of forms and shims, area occupied by shims shall be filled and the area between the base and the edge of the foundation shall be finished smooth to allow drainage away from the base. Interconnecting piping and machinery shall not be attached to the machinery before anchor bolts are tightened. It is desirable to make these connections at least three days after grouting. During the period, cure the grout with wet rags.

26.22-1.17 Only fresh Portland cement conforming to IS: 269 should be used and cement required for grouting will be in the scope of CONTRACTOR.

26.22-1.1.8 Sand used shall be such as to produce a grout with good workability and without any tendency to segregate.

26.22-1.1.9 Sand for general grouting (grout thickness 25 mm and over but less than 50 mm) shall be graded within the following limits :

Passing IS 2.36 mm sieve ….. 95 to 100%
Passing IS 1.18 mm sieve ….. 65 to 95%
Passing IS 300 micron sieve ….. 10 to 30%
Passing IS 150 micron sieve ….. 3 to 10%

26.22-1.1.10 Sand for fluid grouts (grout thickness under 25 mm) shall have the fine materials passing the 300 and 150 micron sieves at the upper limits specified in Clause 1.1.9 above.

26.22-1.1.11 Sand for stiff grouts (grout thickness 50 mm and above) shall meet the usual grading specifications for concrete.

26.22-1.1.12 After all ingredients are added, the batch shall be mixed for 2 minutes. Batches of grout shall be small enough so that the batch may be fully used up in less than 45 minutes.

26.22-1.1.13 The proportions of grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage. The grout proportions shall be limited as follows :

Use	Grout thickness	Mix proportions	W/C ratio (Max.)
Fluid mix	Under 25 mm	One part of Portland cement to one part of sand	0.44
General	25 mm and over but less than 50 mm	One part of Portland cement to 2 parts of sand	0.53
Stiff mix	50 mm & over	One part of Portland cement to 3 parts of sand	0.55

26.22-1.1.14 **Special Non-shrinking Grout**

26.22-1.1.14.1 Proprietary material of approved manufacture used as an admixture to obtain non-shrinking grout shall be mixed as per manufacturer's instruction.

26.22-1.1.14.2 Pre-mixed non-shrinking grout shall be used all as per manufacturer's instructions and without any additional materials / admixtures such as cement, etc.

26.22-1.1.15 All materials, workmanship and finished construction shall be subject to the continuous inspection and approval of the PURCHASER.

26.22-1.1.16 All materials supplied by CONTRACTOR and all work or construction performed by CONTRACTOR rejected, as not in conformity with the specifications and drawings, shall be immediately replaced at no additional expense to the PURCHASER.

26.22-1.1.17 Preliminary approvals of any materials or phase of work shall in no way relieve the CONTRACTOR from the responsibility of supplying grout and or producing finished grout in accordance with the specifications and drawings.

26.22-1.1.18 All grouting shall be protected against damage until final acceptance by PURCHASER or his representative.

26.22-1.1.19 Upon the completion of grouting work, all forms, equipment, construction tools, protective coverings and any debris resulting from the work shall be removed from the area as directed by PURCHASER.

26.22-1.1.20 All debris, i.e. empty containers, scrap wood, etc., shall be removed to 'dump' daily or as directed by the PURCHASER.

26.23-1.0 NOTICE ON VARIATIONS

26.23-1.1 If the PURCHASER shall make any variation in any part of the works such reasonable notice in writing shall be given to the CONTRACTOR as will enable him to make his arrangements accordingly. In cases where systems , structures, components is already manufactured, or in the course of manufacture, or any work done or drawings or patterns made required to be altered, a reasonable sum in respect there of shall be allowed by the PURCHASER. If, in the opinion of the CONTRACTOR any variation is likely to prevent or prejudice the CONTRACTOR from or in fulfilling any of his obligations under the Contract, he shall notify the PURCHASER thereof in writing and the PURCHASER shall decide forthwith whether or not the same shall be carried out. If the PURCHASER confirms his instructions in writing the said modifications shall be modified to such an extent as may be justified. Until the PURCHASER so confirms his instructions they shall be deemed not to have been given.

26.23-2.0 NOTICE OF DEFECTS

26.23-2.1 During the guarantee period, if any defect shall appear or damage occur due to the defective materials, workmanship or design or from any act or omission of the CONTRACTOR, PURCHASER shall forthwith inform the CONTRACTOR thereof stating in writing the nature of the defect or damage. The CONTRACTOR shall remedy all defects/damages or replacements or renewals to the satisfaction of the PURCHASER.

26.23-3.0 NOTICE FOR DELIVERY

26.23-4.0 NOTICE OF TESTS

26.23-4.1 The CONTRACTOR shall give to the PURCHASER advance notice in writing of the date after which he will be ready to make the Tests on completion. Unless otherwise agreed the tests shall take place within 10 days after the said date or days as the PURCHASER shall notify the CONTRACTOR in writing.

26.23-5.0 NOTICE TO CONTRACTOR

26.23-5.1 All notices, written orders etc. to be given to the CONTRACTOR by the PURCHASER under any of the provisions of the contract shall without limitations be conclusively deemed to have been received by the CONTRACTOR if delivered or mailed to the CONTRACTOR at the CONTRACTOR’s address mentioned in the work order or to the CONTRACTOR’s last known place of business or residence or to his Resident Engineer.

26.23-6.0 NOTICE TO PURCHASER

26.23-6.1 Any notice to be given to the PURCHASER under the terms of the contract shall be served by sending the same by post, or leaving the same at the addresses nominated by PURCHASER.

26.23-7.0 NOTICE ON CHANGE OF ADDRESS

26.23-7.1 Either party to the contract may change its nominated address by prior written notice to the others.

26-24-1 General

Commissioning is defined as 'the process during which the plant equipment and systems after having been constructed and tested individually, are made operational and verified to be in accordance with design intent and requirements and to have met the performance criteria'. It includes all tests prior to commercial operation of the plant. CONTRACTOR shall note all the requirements as described in this section for carrying out the satisfactory commissioning of the plant included in the scope of the package.

26-24-1.1 Objective

Carefully planned and executed commissioning is a pre-requisite to the collection of basic information vital to the subsequent safe operation of the plant. Accordingly, a detailed programme of commissioning activities shall be prepared by CONTRACTOR.

The action required to carry out commissioning shall be performed logically and sequentially and shall give due regard to station safety. In carrying out commissioning, the aim shall be to verify design intent i.e. to check the proper installation of structures, systems and components and their instrumentation, to start tests for the acceptance of installed components, to test individual system and progress to integrated system tests, then finally demonstrate safe operation of the plant as a whole. These actions shall also permit the operating and periodic test procedures to be verified and shall train the operating personnel of PURCHASER to become familiar with operating characteristics and maintenance aspects of the plant.

Commissioning tests shall demonstrate the adequacy of the design and generate base line data and operating procedures for safe operation of the plant.

While the production of rated electric power is no doubt of prime importance, the other aspects on which commissioning shall lay equal emphasis, are safety of personnel in the plant and also safety of the plant equipment.

Major efforts of the Commissioning shall be directed to accomplish these objectives in a manner as efficient, safe and informative as possible.

26-24-1.2 Scope of Commissioning

Complete commissioning of Turbine Island as per the scope of this package starting from pre-commissioning checks till final commercial operation is in CONTRACTOR's scope. CONTRACTOR shall work in close co-ordination with PURCHASER's commissioning team and render all necessary co-operation for successful commissioning of Turbine Island. All the pre-commissioning activities before Phase-C commissioning shall be carried out by CONTRACTOR independently, however with close co-ordination with PURCHASER's commissioning team. Commissioning activities during Phase-C shall be carried out by PURCHASER's with close association with CONTRACTOR. CONTRACTOR shall depute all necessary technical man power to carry out the commissioning activities and rectify any problems/difficulties encountered during commissioning.

A commissioning group with an independent QA group shall be set up by CONTRACTOR to execute the over all commissioning programme for the complete plant included in the scope of this package. The scope of commissioning shall include but not be limited to following:

i) Preparation of over all commissioning activities and test Sequence diagrams for each system.

ii) Identification of the major commissioning activities and stages of commissioning.

iii) Preparation of commissioning procedures as per format given by PURCHASER. This format will be given to successful bidder.

iv) Compilation of all pertinent documents and information, equipment data cards, Service Records, Test Records or Certificates, Alignment data, Calibration data, Copies of relevant construction, inspection and manufacturer correspondence required for commissioning.

v) Initial inspection of the system as installed and verification:

   a) What items must be added or corrected before starting operational testing?

   b) What extent of testing is to be done, and changes in the procedures that have already been written?

   c) What level of system cleaning needs to be done?

vi) Ensuring that construction staff takes immediate corrective action on the system deficiencies as found after inspection and the same is recorded in construction completion certificate (CCC). This shall be further certified by QA.

vii) Carrying out modification whenever in a system it is required.

viii) During commissioning, the various activities/tests are carried out to confirm that the design intent is met. At each stage data shall be recorded in supporting documents for test records. The standard commissioning records which are required shall include base line data sheets for various equipment, test procedures, test logs, data collection sheets, installation and completion certificates, standard test sheets, summary of test reports, records of deficiencies noted during commissioning and corrective action taken, final test reports and records of verification of documents like operating manuals and procedures, maintenance procedures and manuals.

ix) Initiate Labelling Programmes for System Identification, Lubrication Instructions, Maintenance Instruction, Operating Precautions and Instructions and labelling programme throughout the commissioning phase.

x) Operability Testing by filling and / or energizing.

xi) For system commissioning the first task is to fill a process system, or energize an electrical or a control system. System performance in terms of

fluid circulations; Energizing of the equipments, electrically, pneumatically or hydraulically as the case may be shall be checked and performance of individual equipments shall be verified under various operating conditions. The system shall be prepared for performance testing in which detailed operating characteristics will be obtained, recorded and analysed.

xii) During system performance test, various tests shall be conducted to confirm that system and equipment perform as per the design intent and to collect base line data for future reference. When a system is in operation, tests must be conducted to establish that system and equipment perform as designed and to obtain data to be used as a base for future tests to determine changes in performance. During commissioning automatic controllers shall be tuned on line and their performance shall be watched over a period of time. Controller settings shall be adjusted for getting optimum performance after ensuring that the system operation is as desired. During this the performance of operating system shall be monitored. This shall define the job of the operator and engineer during normal operation. Operating Procedures shall be checked during this period and revised wherever necessary.

xiii) Diagram of all test setups and list of test equipment used shall be prepared so that test can be reproduced if desired. All this shall be in the end, be part of the commissioning report.

xiv) Taking photographs / video recordings where these would aid to diagrams and descriptive reports. Labeling for details / sequences of photography / video recording also should be carried out for ease of reference at a future date.

xv) Start maintaining the system Chemistry.

xvi) Attend to tasks necessary to the operation of a power station:

a) Training of PURCHASER's personnel in the technical, maintenance and operating aspects. Preparation of field check lists for the same.

b) Preparation of a list of routine tests, checks, logs, etc. and ensuring adequately trained personnel to follow these reliably.

c) Continuously ensure that adequate stored quantities of consumables, spare parts and maintenance tools exist, to cover anticipated situations.

d) Assure that adequate operating and maintenance procedures exist which includes equipment history cards and preventive maintenance procedures.

e) Establish a QA programme for commissioning to enhance the quality during commissioning.

xvii) Protective device of all equipments shall be tested and performance reports shall be recorded

Commissioning of turbine cycle with nuclear steam will be carried out in Phase-C. CONTRACTOR shall note the various aspects of commissioning and various tests to be carried out as a part of commissioning, brought out here and prepare a comprehensive commissioning plan and submit to PURCHASER for his approval.

26-24-2 COMMISSIONING PHASES

The commissioning programme of Pressurised heavy water nuclear power plant will be carried out by PURCHASER. However the turbine island commissioning shall be carried out by CONTRACTOR in consultation and along with PURCHASER. Complete commissioning program of Pressurised heavy water nuclear power plant is divided in to four distinct phases as follows:

Phase-A: Pre operational and commissioning tests including hot conditioning, fuel loading and bulk addition of heavy water to PHT and Moderator.

Phase-B: Initial approach to first criticality and low power Physics experiments.

Phase-C:

- Initial system performance tests at low, medium and rated power levels.
- System performance test at rated power level.

Commissioning of turbine cycle with nuclear steam will be carried out in Phase-C. CONTRACTOR shall note the various aspects of commissioning and various tests to be carried out as a part of commissioning, brought out here and Prepare a comprehensive commissioning plan and submit to PURCHASER for his approval.

26-24-3 Preparation of Operation Flow-Sheets, Commissioning Procedures, Operating Manuals and Emergency Operating Procedures

CONTRACTOR shall prepare operational flow sheets. For operational purpose and the ease of understanding of the systems, the flow sheets should show not only the piping arrangements but also the complete instrumentation, power supplies and interlock logic arrangement details. A set of these, retained in the control room duly updated is the sole comprehensive guide to the system and control devices in the station.

The preparation of commissioning procedures, to work out steps and sequence by which systems are made operational, to ensure that the systems behave as per design intent. CONTRACTOR shall include but not be limited to following check list in the commissioning procedure

1. Cold & hot readings of spring supports.

2. Check the free movement of the pipe line when the line is heated up.
3. Note down the thermal movement of the pipe when the line is heated up at relevant locations.
4. All the temporary supports are removed before the line is heated up.

The preparation of operating manuals, for detailed study and these shall give the following information.

i) Description and general information with important operating parameters.
ii) Interlocks and protections with settings.
iii) Hazards and precautions during operating and shutdown conditions.
iv) Description of shut down state, poised state and operating state.
v) Initial startup procedure and operating procedure.
vi) Normal operating procedures and checks.
vii) Action on system/unit trips.
viii) Standard isolations and procedures.
ix) Alarms, effects on system and operator action.
x) Abnormal operations.
xi) Power and air failure.
xii) Start up of the system
xiii) Shut down of the system
xiv) Chemical control aspects.
xv) Effect of non-availability of the particular system on plant operation and safety.
xvi) Interrelation with other plant system.
xvii) Technical specifications relevant to the system.

During the actual commissioning, the flow sheets and operating manuals shall be updated as dictated by the commissioning experience. The obsolete flow sheets and operating manuals etc. are removed and replaced with latest revised copies.

26-24-3.1 Procurement and Inspection of Spares and Preparation of Maintenance Manuals

Based on the CONTRACTOR's experience and the available feed back from the similar equipments in the operating stations the CONTRACTOR shall assist commissioning group to prepare a list of sufficient spare parts. Though enough spares for 5 years operation are taken care of while procuring equipment, adequacy of the spares so ordered shall be checked and action taken where necessary. Maintenance manuals shall also be prepared by CONTRACTOR.

26-24-3.2 Preparation of Commissioning Documents

26-24-3.2.1 General

The Commissioning documents shall be written with the earlier commissioning experiences with similar stations and in consultation with the designer to ensure that the design intent is met and system is tested for confirmation during commissioning.

26-24-3.2.2 Test sequence diagrams (TSDs)

The test sequence will be prepared in the form of an arrow diagram indicating various activities and their sequence.

26-24-3.2.3 Commissioning Procedures

Commissioning procedures shall be written to describe in detail how individual equipment / component / system / structure will be checked, inspected and functionally checked. The following information shall be covered in each procedure:

i) Purpose
ii) Design intents to be verified
iii) Pre-requisites
  a) System Requirement from Other Systems
  b) System Requirement
  c) Special Instruments
  d) Manpower Requirement (including requirement from outside agencies, if any)
iv) Detailed Procedure
v) Expected Parameters at Various Power Levels
vi) Data Sheets
vii) Verification Process
viii) Hazards and Precautions

26-24-4 COMMISSIONING REPORTS

26-24-4.1 Interim Reports

In many systems where commissioning activities are linked to other systems and where these are to be undertaken in two or more stages, Interim Reports shall be issued after completion of activities in each commissioning stage. These reports shall also contain the deficiencies existing in the system so that the same can be corrected prior to the commencement of next phase of commissioning of system. It shall contain the present test data also.

26-24-4.2 Final Commissioning Report

This report shall be written when the system is in operation to the satisfaction of the Operation and Maintenance groups and shall summarize the work done, tests conducted and present status of the system. It shall include:

i) Introduction
ii) Summary of test objectives
iii) Appropriate test procedures and other cross references

iv) Test description/Commissioning work sequences
v) Organisation for commissioning work sequence, description of special test equipment/set-up used (if any).
vi) Diagrams and photographs of the system/equipment
vii) Observation/test data and analysis
viii) Evaluation of results
ix) Designers comments
x) Conclusion
xi) Any deviation in approved procedure
xii) Modifications made during commissioning phase, list of drawings through these changes are affected and their status.
xiii) System deficiencies/limitations, if any.
xiv) Acceptance criteria and designer's comments before concluding a system to have been commissioned.
xv) Ease of operation and maintenance of equipment, valves etc., should be brought out as a feed back for future refurbishments/decommissioning planning.
xvi) List of documents and reports.

All necessary steps shall be taken to ensure no operational problems arise in future. This shall consist of:

- Operational features of the system and component with feasibility of maintenance of failed component without taking a shutdown.
- Arrangement of sufficient spare parts.
- Initiation of detailed In-service inspection (ISI) and testing programme.
- Initiation of all surveillance and routines.
- Issue of updated operating manuals.
- Updating of the drawings to as built conditions.

26-24-5 COMMISSIONING WORK SEQUENCE

26-24-5.1 Equipment Performance Testing

Efforts shall be made to test most of the equipment after installation at site to ascertain their capabilities to give rated outputs and reliability after rectification of deficiencies. This becomes essential for those equipments which are non standard items and have been fabricated for the first time or specifically fabricated to suit the requirements. Though the purpose of commissioning tests also is the same, equipment tests provide the advantage of testing the equipment much earlier since the testing does not have to wait for the entire system to be made ready.

26-24-5.2 Pre-Service Inspection & Collection of Base Line Data

Post operational in service inspection: As a part of quality assurance for monitoring the performance, pre-service inspections and base line data collection shall be carried out for various system, structure and equipments and also base line data like signature analysis for vibration is taken for rotating equipments. A

detailed ISI Programme which includes specific checks to be carried out on different types of equipment shall be worked out.

26-24-5.3 System Transfers (Construction to Commissioning/ Operation)

Before starting commissioning following inspection shall be carried out along with PURCHASER's personnel:

i) Are there any foreseeable safety hazards, which should be removed during commissioning / operation? (e.g.: Sufficient head room for safe movement of personnel)?

ii) Is access possible where required by way of manholes, clearances for opening of covers, removing and reinstallation of equipments and parts?

iii) Are mechanical handling facilities adequate?

iv) Is identification complete on pipes, valves, equipment, and panel switches?

v) Is physical support of field equipment adequate?

vi) Are pumps likely to gas-locked?

vii) Is equipment isolation possible?

viii) Is air pressure to valve positioners adequate and correctly provided?

ix) Is lubrication to motors, pumps, valves, dampers adequate?

x) Have all blanked off flanges been restored to normal?

xi) Whether gags from all relief / safety valves removed after hydro test?

xii) Is the system clean?

xiii) Are the vents and drains adequate to ensure complete draining of water from the systems?

xiv) Are various field instruments, gauges provided are easily readable?

xv) Verification of details given on equipment / valves name plates vis-à-vis specifications given in design documents.

xvi) Orientation of valves and equipment with reference to flow direction.

xvii) Ease of operation and maintenance for various equipments, valves, piping and other facilities with respect to layout shall be checked.

xviii) Painting is carried out as per colour code?

xix) Condition of insulation on the piping and equipment.

xx) Are physical isolations available for the systems which are still not handed over for commissioning or from 1^{st} /2^{nd} operating unit?

xxi) Whether any changes / modification were carried out w.r.t approved drawings? Status of all such modifications?

xxii) Piping vibration-affecting instrumentation.

The above activities shall be jointly carried out by the O&M, Construction, QA, and Field Engineering Groups. Following records shall be compiled-

- Records of alignment (equipment as well as pipe flanges)
- Calibration records
- Contact setting records
- Status of wiring checks and marked up elementary or control drawings mentioning jumpers if any
- Records of testing on relief and safety valves from valve testing facility
- Pneumatic test / Hydro test / Helium leak test reports
- List of spares received
- List of Manufacturer's instructions and relevant literature.

The equipment is then tagged with "Taken Over by Commissioning" Tags. The terminal points are also clearly marked and tagged.

26-24-5.4 Preoperational Checks

26-24-5.4.1 General

The commissioning checks will include but not be limited to:

Mechanical Checks: Alignment, lubrication, freeness of equipment, couplings, tightness of bolts etc.

Electrical Checks: Insulation resistance, PI value, earthing connections, space heater in motors, motor control center cubicles and continuity checks, protective relay settings etc.

Instrumentation: Installation, Calibration, contact settings, logic circuitry etc.

Piping and Equipment: Checking line by line against the operational flow for completeness of system.

26-24-5.4.2 Control and Logic Checks

Control devices, which indicate and have movable contacts, shall be checked at 20% and 70% of scale. Recorders or remote indicators shall be checked along with transmitters. Temperature critical detectors (RTD) etc shall be checked by constant temperature bath, while calibration on non critical/conventional measurements will be done by hot bath checks.

Detailed logic checks shall be carried out as per commissioning procedures which shall include continuity checks wiring specifications, numbering and possibility of any loose connections. Annunciation circuits shall be checked by simulating alarms by opening or closing the particular device or relay contacts. Operating circuits shall be likewise tested for correct operation of interlocks by simulation or in the real manner. Operating tests on valves etc. shall then be carried out.

26-24-5.4.3 Filling, Venting and Initial Circulation

To prevent transportation of construction debris to critical parts of system installation of temporary strainers shall be considered before initial circulation (for

flushing) is carried out. The pipeline shall be filled with the system fluid and vented if required. The associated electrical equipment and controls are energized. Initial circulation is carried out after open loop flushing and during circulation pressures. Flows, motor currents, vibration data etc., shall be recorded. All records shall be kept on "Commissioning Logs" sheets and interim commissioning reports are made out where necessary. The system is now ready for performance tests. Integrated system Hydro/Pneumatic/ Helium tests (where applicable) shall be carried out after system flushing which includes flushing of instruments impulse lines. Wherever rotating equipment arc required for flushing operation, commissioning of the motor first on no load, checking the direction of rotation and marking the direction of rotation is to be carried out and then only the equipment should be coupled.

26-24-5.4.4 Manufacturer's Assistance

During the start of certain major equipment, the presence of the Equipment manufacturer's/designer's representative may be required to ensure that the supplier is satisfied with the equipment installation before and during the initial runs. This will help in the assessment of the equipment performance in terms of the warranties.

26-24-5.4.5 Performance Tests

The system liquid chemistry shall be brought to the specification requirement by adding chemicals and maintaining circulation. Signals shall be introduced to check system response, tests are also done to check "changing over" of pumps on auto and manual operation. Indicating meters, lights, annunciation and controls shall be checked as in routine operation. Startup, steady state operation and shut down and system response to transients shall be completed.

When all the systems are tested, the overall multi-system testing shall be performed. On completed items final commissioning reports shall be issued.

CONTRACTOR shall note that commissioning with nuclear steam of turbine generator and secondary cycle will commence with the start of Phase-C commissioning. Details of Phase-C commissioning are described below. CONTRACTOR shall note the various activities and tests which are described below which he shall include in his commissioning program-

26-24-6 Phase-C Commissioning (Power Run Up, 0.1% to 100% of Full Power)

Major events

i) Stepwise power operation with the station synchronized to the grid (50% FP, 75% FP and 100% FP)

ii) Tests to prove reactor, boiler and turbine generator capabilities.

iii) Data collection and final report.

26-24-6.1 Power Operations

Raising Power to 5-10% FP

The phase 'C' of the programme starts with the raising of reactor power from 0% FP to 5-10% FP. Steam is generated in the boiler and dumped into the condenser by the steam turbine by-pass system. Power will be raised manually.

The reactor power will be held at 5% FP and regulating and protective systems will be checked for smooth auto operation.

Reactor power is raised to 10%. Steam will be used to warm and roll the turbine. All system parameters shall be noted on data sheets. Following system cheeks are planned at this stage

i) Setting of Main steam safety valves and deaerator relief valves before TG rolling.
ii) Condenser vacuum pulling
iii) ASDV Tests
iv) Turbine rolling and various tests
v) TG tests

Special observation will be made of fuel channel, temperature distribution to see if any variations exist due to reactivity state of the core and coolant flow variation. PHT D_2O temperature coefficient is also measured.

A Class IV failure test will be conducted to test the performance of the unit and also to give station personnel experience of handling such situations.

50% FP

The load will he raised to 50% FP. Gross load rejection test shall be done to check turbine performance, data shall be collected. Thermal power calibration will be done and net efficiency shall be calculated.

Holding at each level (At power levels of 50% FP and beyond):

During the power increase, the power level will be held at successive levels to test the performance of the generation unit. Also predictions will be made for the next higher power level. Only when the performance at a given level is satisfactory as noted on check sheets the power will be raised to the next level. At 50% FP a net load rejection test shall also be carried out. Stand by Boiler feed pump spurious start test and trip test of running boiler feed pump shall also be carried out.

75%FP

The unit will be loaded to 75%. Thermal power calibration will be done. Heat rate and station net efficiency will be calculated. Turbine run back will be initiated to check turbine performance. Similarly, condenser vacuum pay off test will be done, gross and net load rejection test and class IV failure test will also be done. CSDV performance test will also be carried out to demonstrate the capability of dump valve to dump minimum 70% of steam and condenser to accept the steam. Stand by Boiler feed pump spurious start test and trip test of running boiler feed pump shall also be carried out.

l00%FP

After attending to the deficiencies noted during power run up which would interfere with steady state full power operation, unit power will be raised to 100% FP.

i) The unit is run at the maximum rated power to demonstrate its power producing capability.

ii) Data collection of various parameters of various systems is carried out for reviewing the performance of various systems. Response checks of Reactor and secondary systems for the following conditions will be done:

a) Reactor power increase/decrease by 2% PP with BPC. BLC, turbine controller and PHT pressure controller on Auto.

b) Reactor set back for 10 seconds and recording the relevant parameters. Also the following tests are conduced at full power:

- gross load rejection test
- Net load rejection test
- steam dumping capacity test
- Main BFP trip test
- Main BFP spurious start test
- Turbine acceptance tests.

26-24-6.2 Purpose of Commissioning Tests

The following will briefly describe the purpose of the tests mentioned above:

i) Unit Dynamics Test

This is to check transient response of the regulating system to step changes in the input signals. Reactor power set back will also form part of this.

ii) Safety Valve Test, Condenser Steam Dump Valve Test, Atmospheric Steam Discharge Valve Test

This is to check the valve settings to make sure they will operate as required.

iii) Class IV Power Failure Test

This is to check how efficiently Class III power will pick up and restore power supply to essential equipments when both the grid and the generator power supply are off, also to ensure that operation of class II switchgear is satisfactory during such an eventuality.

iv) Class IV and III Power Failure Test

Class IV failure test will be done without the DG sets on auto. The time taken for bringing the DG sets into service by manual start in the shortest time possible and the ability of the batteries to supply class I loads during this period will be studied.

v) Turbine Generator Run Back Test

This will prove the turbine performance as the power is lowered at 0.25% FP per second.

vi) Gross and Net Load Rejection Test

a) Unit will be operating at 100% FP. Only 400 KV generator breaker will be tripped. (net load rejection test) The turbine should not trip and continue to supply unit auxiliaries.

Steam dump valves should open fully and also atmospheric SDV's should open and initiate reactor power set back till power is lowered to approximately 70% FP equal to steam dump valves capacity in house load on TG. Then SDV's should close and dump valves should remain open. The speed rise in turbine and rise in Boiler Pressure and rise in PHT pressure will be observed. The reactor should not trip for such an event.

b) All the class IV loads will be transferred to SUT and then with the unit supplying 100% electrical power, the 400KV generator transformer breaker will be tripped (Gross Toad rejection test). Sequences will be as in 'a'. The speed rise in turbine and the capability of turbine and reactor to withstand the disturbance will be checked.

c) With unit operating at 100% full power, Reactor trip will be initiated. The TG trip, auto transfer of 6.6 KV supplies will be checked and ability to come back to full power will be established.

d) With the unit operating at 100% FP, the turbine trip will be initiated. Generator breaker opening through low forward power and action of Boiler pressure control will be checked. Reactor should not trip but power only reduced to approximately 70% FP a value corresponding to steam dump valves capacity. Steam dump valves should open fully.

High speed recorder shall be used to record the following variables on the chart for analysis.

- Turbine generator speed
- Speeder rate
- Generator output
- Boiler pressure
- Reheat steam pressure
- Feed water flow and temperature
- Emergency stop and control valve positions
- BPC Signal
- Heat transport header pressure
- Regulating system set point
- Linear neutron power
- Thermal power

Contacts of: Gen. Breaker

Line Breakers
Turbine Trip
Reactor Trip
Steam Discharge Valves, Steam Dump Valves.

This test will prove that turbine governing system capability as per design, load throw off curve and setting of 'DROOP" of Governor. Depending on the grid capability to withstand the transient, this may not end in Class IV power failure.

vii) Acceptance Tests

Acceptance tests will be done on the turbine generator, in order to determine turbine generator and Feed water cycle performance with respect to

a) Net heat rate in terms of Kcal/KWh for 60%, 80% and 100% of rated electrical output in MW after deducting driving power for motor driven auxiliaries, during 24 hours continuous operation at rated conditions.

b) Net thermal efficiency, derived from net heat rate.

c) Maximum electrical output in MW and MVA across generator terminals at Voltage, 50 c/s and design PF; for condenser design vacuum and condenser cooling water temperature of design. Necessary correction factors for different cooling water temperature for condenser, C.T. and P.T. ratio errors, C.T., P.T. and Wattmeter potential coil phase angle errors as applicable, based on Manufacturers performance curves and test reports.

d) Net electrical output after deducting auxiliary consumption which is measured on high voltage side of Unit aux. transformer and low voltage side of station startup transformer.

e) Inter stage and loop drains information.

f) Makeup losses.

g) Steam quality.

h) Condenser back pressure versus load MW output.

i) Moisture separator efficiency etc.

26-24-6.3 Data Collection

During Phase-C when most of the systems will be approaching their hot' operation for the first time, system parameters like flows, pressures, process temperatures, metal temperatures etc., shall be observed to ensure that they are within design limits. Data evaluation shall be completed during steady state operation of the unit at full power.

One of the main objectives of the Phase-C operation is to prove that there are no limitations to raise the unit to full power. By the various tests mentioned above as well as routine reliability tests on the safety systems, regulating and protective systems, the turbine and generator should have been checked for stability and reliability, for full power operation.

The drawings enclosed with the package are covered in section C-2 in each individual chapters for specific technical requirements.

28.1 INTRODUCTION

28.1.1 The procedure contained in the following paragraphs are to be followed by CONTRACTOR. References to CONSULTANTS in the following paragraphs are applicable if PURCHASER appoints CONSULTANTS.

28.2 Identification of key personnel

28.2.1 The names, designations, postal addresses, telephone numbers, e-mail IDs, fax numbers of the representatives of the contracting parties shall be identified as per Annexure-1 enclosed.

28.2.2 In the following paragraphs, 'PURCHASER', 'CONSULTANT' and CONTRACTOR' shall be deemed to mean the personnel identified in Annexure-1.

28.3 Correspondence Procedure

28.3.1 All correspondence between the contracting parties shall be in triplicate. The CONTRACTOR shall address all his correspondence to PURCHASER.

28.3.2 All correspondence on purely commercial matters shall be sent to PURCHASER only. No copies shall be marked to CONSULTANT.

28.3.3 All letters shall bear a reference number which should contain a continuously running serial number. This would enable the PURCHASER to identify if any letter or document is misplaced.

28.3.4 The CONTRACTOR shall be responsible for coordination of all activities with his sub-contractors (if any).

28.4 Co-ordination Meetings

28.4.1 The CONTRACTOR shall note that he will be called upon to attend meetings with PURCHASER and his representatives, CONSULTANT and other contractors during the execution of the contract. Such meetings will be held periodically once in about 3 months or earlier as considered necessary. The PURCHASER/CONSULTANT will organise such regular meetings. The agenda for coordination meetings shall be issued by CONTRACTOR or PURCHASER or CONSULTANT to each of the other two parties at least three (3) weeks in advance of meetings. The CONTRACTOR shall attend all such meetings at his own cost as and when required and fully cooperate with all persons and agencies involved during these discussions. The venue of the meetings would be decided in advance to suit the convenience of all parties. The PURCHASER/CONSULTANT will sort out and resolve the various technical matters and outstanding issues as necessary in such meetings. In these meetings, manufacturer's progress and overall project schedule will also be discussed. Minutes of meetings shall be drafted by the agency at whose office the meeting is held

and the same shall be finalised and signed by all parties before the close of the meeting. The distribution of minutes will be

a) to PURCHASER - 3 copies
b) to CONTRACTOR - 3 copies
c) to CONSULTANT - 3 copies

28.5 Procedure for submission of CONTRACTOR'S drawings/documents

28.5.1 The CONTRACTOR shall prepare a complete list of all drawings and documents, to be prepared and submitted to PURCHASER in the process of Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over and as called for in this specification, and shall submit to PURCHASER within the time limit as indicated in Letter of Intent/Purchase Order. This drawing and document schedule shall indicate title of the drawing or document, document no. or drawing number, expected date of submission, actual date of submission and purpose of submission (i.e. whether for information or for approval) etc., as per engineering schedule agreed to with the PURCHASER.

28.5.2 Six copies of all the drawings/documents submitted by the CONTRACTOR shall be forwarded to PURCHASER for approval or information under cover of a transmittal form only and not a letter. Any written communication that the CONTRACTOR might wish to make to PURCHASER while forwarding a drawing or document shall be in the form of a detachable memo and shall be sent along with the forwarding transmittal.

28.5.3 Each and every drawing or document including write ups, data sheets, etc. shall carry project title, names of PURCHASER AND CONSULTANT, PURCHASER's drawing/document No., revision number, date of revision and brief details of revisions carried out, appropriate ref. no. of schedule, distribution and purpose, etc. Wherever any revision is carried out, correspondingly revision number must be updated. The revisions carried out on any drawing or document shall be identified by encirclement and tagging the encirclement with the revision number. A drawing not complying with this procedure will not be reviewed by PURCHASER. The receiving parties shall return one copy of transmittal form duly signed as acknowledgement of receipt to originator, noting discrepancies, if any.

28.5.4 Please refer to Annexure-1 enclosed in this section for distribution.

28.5.5 All documents shall have English version on them.

28.5.6 All dimensions on drawings shall be in metric units, unless otherwise specified. If any dimension figured on a drawing differ from those obtained by scaling the drawing, the dimension as figured shall be taken as correct.

28.5.7 Immediately after award of contract, CONTRACTOR shall compile a list of mutually agreed deviations to the Procurement Specification. The procurement specification along with the list of mutually agreed deviations constitute the contract document which forms the basis of Contractor Drawing Review.

28.5.8 Review of CONTRACTOR'S documents/drawings by the PURCHASER will be on one-unit basis wherever documentation is identical for both units. However for subsequent units, CONTRACTOR shall certify in the documents/drawings that the information contained in the documents/drawings is identical with the one already reviewed and approved by PURCHASER.

28.5.9 Depending on the completeness and correctness of CONTRACTOR'S drawings/ documents recommended for approval, the same will be stamped as below:

NUCLEAR POWER CORPORATION OF INDIA LIMITED
CONTRACTOR DRAWING REVIEW STATUS

() Approved

() Approved subject to comments as noted.
Proceed with fabrication considering comments.
Submit revised drawings and reproducibles for
Records.

() Not approved. Revise as per comments & resubmit
for approval.

() Refer covering letter No. ----------
dated ----------.

() Drawing of this category is not reviewed.Drawing
received for information only.

Reviewed by : _____ Date :

Approval herein neither relieves CONTRACTOR of his contractual obligations and responsibilities nor does it limit PURCHASER'S rights under the contract.

28.5.10 The CONTRACTOR shall resubmit those drawings & documents on which clarifications/modifications have been sought. This shall normally be done within 2 weeks of receipt of comments, if not otherwise specified in engineering schedule.

28.5.11 Drawings which are resubmitted by CONTRACTOR without incorporating all the comments made by PURCHASER and without any clarifications for non- compliance with comments made will be deemed incomplete and will neither be reviewed further nor approved.

28.5.12 Should there be a delay in furnishing comments or according approval to the drawing/document with respect to the agreed engineering schedule, the party issuing the drawings should immediately notify the other party about likely implications on delivery or construction activities. Such disputes must be mutually discussed and resolved at the earliest.

28.5.13 Any work performed or material ordered by the CONTRACTOR prior to receipt of drawings stamped 'Approved with comments as noted' by the PURCHASER shall be at the risk of the CONTRACTOR. After print of any drawing has been returned 'Approved', the CONTRACTOR may release all parts covered by the drawing, for production.

28.5.14 Two reproducible of finally approved drawing shall be sent to the PURCHASER along with six prints and soft copy. This shall also be through transmittal form.

28.5.15 Examination and approval of the drawings by the PURCHASER shall not relieve the CONTRACTOR of his responsibility for engineering, design, workmanship and materials, under the Contract.

28.5.16 Any delay in the approval of CONTRACTOR'S drawings and documents by PURCHASER due to non-compliance of the above procedural requirements by CONTRACTOR shall be entirely to CONTRACTOR'S account.

28.5.19 SECRECY

28.5.19.1 The technical information, drawings, documents, specifications and other related documents forming part of the enquiry or 'Contract' are property of the PURCHASER and shall not be used for any other purpose, except for execution of the 'Contract'. All rights, including rights in the event of grant of a patent and registration of designs are reserved. The technical information, drawings, specifications, records and other documents shall not be copied, transcribed, traced or reproduced in any other form or otherwise in whole and/or duplicated, modified, divulged and/or disclosed to a third party nor misused in any other form whatsoever, without the PURCHASER'S prior consent in writing, except to the extent required for the execution of this 'Contract'. These technical information, drawings, specifications and other related documents shall be returned to the PURCHASER with all approved copies and duplicates, if any, immediately after they have been used for the agreed purpose.

28.5.19.2 In the event of any breach of this provision, the CONTRACTOR shall indemnify the PURCHASER from any loss, cost or damage or any other claim whatsoever from any parties claiming from or through them in respect of such breach.

28.6 PLANNING AND SCHEDULING

28.6.1 After the award of Contract the CONTRACTOR shall plan the sequence of work of Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation, performance testing and handing over to meet the agreed Plant commissioning date and shall ensure that all work proceed in accordance with the required sequence. The CONTRACTOR shall furnish the dates of Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation and handing over or stages of work as called for in the schedules.

28.6.2 Within one month of LOI/PO (purchase order) the CONTRACTOR shall submit two copies (1 reproducible, 6 print) of 'Network Schedule' to the PURCHASER showing the logic and period of activities for review and approval.

The schedule shall cover the complete contract work. The approved Network Schedule shall be binding on the CONTRACTOR.

28.6.3 During the execution of the Contract, if it is found necessary to change the schedules, the CONTRACTOR shall inform the PURCHASER and submit a modified Network Schedule with adequate reasons and evidence to the satisfaction of the PURCHASER. Such approval is not to be deemed consent to any amendment to the completion date as stated in the schedule.

28.6.4 The Network Schedule shall be updated every month or at a frequency mutually agreed upon.

28.6.5 Access to the CONTRACTOR'S and SUB-CONTRACTOR'S Works is to be granted to the PURCHASER/CONSULTANT at all reasonable times for the purpose of ascertaining progress.

28.7 PROGRESS REPORTS FOR PROJECT MONITORING

28.7.1 During the execution of the contract, the CONTRACTOR shall furnish monthly progress reports to the PURCHASER in a format as specified by the PURCHASER indicating the progress achieved during the month and total progress up to the month as against scheduled and anticipated completion dates in respect of key phases of Design & Engineering, Manufacture, Procurement, Erection / Construction, commissioning & testing , trial operation and handing over and shipment such as release of drawings for fabrication, inspection, testing and shipment. The progress reports shall indicate all delays anticipated by CONTRACTOR along with reasons for the delays. If called for by the PURCHASER the CONTRACTOR shall also furnish resource data and any other information in a specified format and frequency.

ANNEXURE-I

NAMES AND ADDRESSES OF KEY PERSONNEL

1. OWNER: NUCLEAR POWER CORPORATION

Mr.
Nuclear Power Corporation of India limited
Nabhikiya Urja Bhavan,
Anushakti Nagar,
Mumbai - 400 094.

Telephone No. ----------. E-mail ID.:.....
Fax No. :.....

2. CONSULTANT (If appointed by PURCHASER) :

Telephone No. ----------. E-mail ID.:.....
Fax No. :.....

3. CONTRACTOR

M/s.
Address :

Telephone No. ----------. E-mail ID.:.....
Fax No. :.....

Name Designation

i. Mr.
ii. Mr.
iii. Mr.

29.1 Following documents shall be submitted for all systems, structures and equipments covered under this specification, apart from other drawings and documents as called for submission in other sections of this specification.

29.2 **Design & Engineering-** For design and engineering phase following documents shall be submitted – Design notes, Design basis reports, design calculations and design manuals.

29.2.1 **Design Notes**

29.2.1.1 Design Notes are basically prepared

(a) with a view to crystallise ideas or concept, arrive at system parameters and bring out various schemes/options, etc.

(b) to obtain methodology of design/detail engineering before the design work is taken-up.

These are based on various design calculations and design studies.

29.2.1.2 All Design Notes shall consider all the options, their effect on full power operation, effect of failure at full design rating and at various operating conditions, maintainability studies, equipment handling procedures, preservation procedures and safety analysis, etc.

The Design Notes should, in general, be prepared covering the following topics.

Scope, Introduction, Purpose, Assumptions, Design Data, Various Options and their merits & demerits, Parametric Studies for arriving at System Parameters, Applicable Codes, Safety & Seismic Classifications, Design Considerations, Computer Inputs / Outputs, Design Calculations, Results, Conclusions, Recommendations, References, Sketches, etc.

29.2.2 **Design Basis Reports**

29.2.2.1 **Classification of DBRs**

DBRs can be classified as follows :

1. Safety related DBRs - Prepared for the Systems/ Equipment/Structures related to safety.

2. Non-safety related DBRs - All other DBRs

29.2.2.2 DBR is a part of licensing documents which is prepared subsequent to or together with preliminary feasibility studies and / or preliminary safety analysis.

29.2.2.3 The DBRs shall be prepared based on the inputs from various system design notes, preliminary analysis covering engineering, process design, material selection, heat balance and thermal calculations, equipment details and layouts, instrumentation requirements and feedback from earlier plants.

29.2.2.4 If proven design is adopted, it shall be clearly stated giving reference to earlier design. Where any modification is made over the proven design concept, same shall be stated clearly giving details of modification and consequence of it. If altogether new design / design concept / modification is adopted, a thorough review of design shall be carried out.

29.2.2.5 Design review shall be carried out for finalisation of the system details considering all consequences of change / modification over the proven design and of new design / design concepts. Methods of verification shall be identified and stated clearly to prove that the design will perform as per the design intent. Design review shall cover all modification over the previous design based on the feedback from earlier station, new design / design concept and system, equipment whose failure to function at full design rating will affect the ability of the plant to function at its design rating under various operating conditions, maintainability studies, equipment handling procedures, preservation procedure and safety analysis etc. Outcome of review shall also provide inputs for the preparation of DBRs.

29.2.2.6 Graded Quality Assurance Programme shall be adopted for finalisation of the system design depending on the safety and operational importance, maturity and complexity of the system / component / structure.

29.2.2.7 **Details of Topics to be Included in DBR (except for Building and Structures)**

The following topics shall be included in the DBRs as a minimum. Additional points, if required, may be incorporated.

29.2.2.7.1 **Scope**

Describe the function/role of the system / equipment / component / structure

29.2.2.7.2 **System Description**

Give description of the system which should also include principal dimensions and locations of the system / equipment. Simplified flow diagrams / process and instrumentation diagrams etc. as applicable may be included as figures/sketches.

29.2.2.7.3 **Logics, Instruments & Control**

Logic for operation, performance of each equipment, instrumentation provided is to be described. Include the following

(i) General,

(ii) Requirement,

(iii) Identification of each equipment, instrumentation loop for monitoring & control,

(iv) Warning system, alarm/ annunciation in control room/control panel.

29.2.2.7.4 **System Operation**

Include system operation/performance under following conditions :

i) Normal operation.
ii) Shutdown.
iii) Operational transients.
iv) Operation under off-normal conditions.

29.2.2.7.5 **Design Approach :**

Following are to be included:

i) Input data and assumptions: Input relevant to DBR should be given with brief summary. Input should be supported by appropriate reference. Assumptions made to be justified by proper basis.
ii) Design basis: of current design should be given. All information to be latest, updated, consistent.
iii) Applicable codes and guides: Reference to be made to AERB design code clauses as and when relevant. Any exceptions to the code should be mentioned and justified. If data from international codes /guides is given the code should be properly referred/mentioned.
iv) Safety and seismic classification.
v) Material selection.
vi) Optimisation studies of various alternatives.
vii) Design analysis and engineering of the system.
viii) Built-in safety features
ix) Consideration of layout.
x) Fire load
xi) Consideration for man-machine interface.
xii) Surveillance, in-service inspection, maintenance and testing requirements. General approach and guidelines shall be given here. Detailed project specific pre- service and periodic inspection requirements are to be given in ISI programme document.
xiii) **Radiological Aspects**: Mention here about location of system/ equipment/component w.r.t. accessibility, shielding, sealing, general occupancy and radiation fields, decontamination case, maintenance case, man-rem for maintenance etc., should be described here.
xv) Reference to earlier similar design/design concept: Give reference to

earlier similar design/design concept and further improvement. If it is a new design / design concept what additional QA programme should be adopted.

xvi) Modification over the proven design: Changes over the previous proven design if any should be stated clearly giving reasons for modification and consequences of it. If it is altogether new design state clearly the uniqueness of design and its; implication on operation in case of malfunction or otherwise.

xvii) Consideration for latest technology, availability of materials, components, procurement, constructability and operability.

xviii) Feedback from earlier station: experience from earlier station should be stated here.

29.2.2.7.6 **Postulated Failures**

Shall include system reliability, single/dual failures, fault sequence analysis and consequence of failure and mitigation.

29.2.2.7.7 **Radiological Consequences**

This sub-section is different than **Radiological Aspects**. Under this sub-section mention consequences of failure of pressure retaining boundary, mopping, recovery provisions, etc.

29.2.2.7.8 **Handling equipment/ approach & maintenance platform and ladder**

The requirement for handling equipment/ approach, maintenance platform and ladder for the system, structure and component shall be indicated in Design Basis Report.

29.2.2.7.8 **References**

Give reference to internal reports/documents feedback reports from earlier plants and published literature. Oral communications should not be cited as reference.

29.2.2.8 **Details of Topics to be Included in DBR for Buildings and Structures**

29.2.2.8.1 **Section-1**

i) Objective
ii) Scope
iii) Structure of the Report

29.2.2.8.2 **Section– 2**

Building description giving functional and structural requirement.

29.2.2.8.3 **Section - 3**

Safety/seismic classification, fire rating etc. and design bases for foundations and superstructures, protection against hazards.

29.2.2.8.4 **Section - 4**

Design Approach - giving applicable codes and standards material specification, loads and load combinations.

29.2.2.8.5 **Section - 5**

Analysis - Static and dynamic analysis method, description of mathematical models.

29.2.2.8.6 **Section – 6**

Design methods and acceptance criteria.

29.2.2.8.7 **Section - 7**

Detailing practices.

29.2.2.8.8 **Section - 8**

Summary and conclusions.

29.2.3 **Design Manual**

29.2.3.1 DMs can be classified as follows :

1. Safety related DMs – Prepared for the systems / equipment / structures related to safety.
2. Non-safety related DMs – All other DMs.

29.2.3.2 The Design Manual is a comprehensive document of the system design. After the design is frozen, the Design Manual shall be prepared to include information covered in and formulae used in the design. Inputs from various analyses such as stress / seismic / vibrations / thermal-hydraulics / development / safety (process and radiological), etc. carried out by different agencies are also be incorporated.

29.2.3.3 **Details of topics to be included in DMs**

Detailed list of topics to be included in the Design Manual as applicable is given below additional information, if required, may be incorporated.

29.2.3.3.1 **INTRODUCTION/SCOPE**

Describe the function / role of the system / equipment / component.

29.2.3.3.2 **SYSTEM / EQUIPMENT DESCRIPTION**

Give description of the system/equipment which should also include principal dimensions and locations of the system/equipment. Give description of process and function of major equipment. Simplified flow diagrams /

process and instrumentation diagrams etc. as applicable, may be appended as figures / sketches.

29.2.3.3.3 **LOGICS/INSTRUMENTATION & CONTROL**

Logics for operation, performance of each equipment, instrumentation provided is to be described. It should include following:

i) General,
ii) Requirement,
iii) Detailed description of each equipment, instrumentation loop for monitoring & control,
iv) Warning system, alarms / annunciation in Control Room/ Supplementary Control Panel.

29.2.3.3.4 **OPERATION**

Include system / plant operation and various performance parameters under following conditions :-

(i) Normal reactor / plant operation
(ii) Reactor / plant shutdown
(iii) Operational transients
(iv) Operation under off-normal conditions

Explain control logics for all equipment (pumps / motorized valves) with identification of equipment, switches, control positions & location.

29.2.3.3.5 **DESIGN APPROACH**

Following are to be included as applicable :

(i) Input data and assumptions
(ii) Design basis, parameters selection
(iii) Applicable codes/classifications
(iv) Materials selection
(v) Optimisation studies of various alternatives
(vi) Design analysis and engineering of the system
(vii) Built-in-safety features

29.2.3.3.6 **INSTALLATION**

Installation aspects, manufactures guidelines, precautions, etc.

29.2.3.3.7 **EXAMINATION**

Non-destructive examination of materials and systems/plants after erection.

29.2.3.3.8 **SYSTEM INTEGRITY TESTING**

(i) Pneumatic
(ii) Hydrostatic/fluid
(iii) Helium leak

29.2.3.3.9 **SYSTEM COMMISSIONING**

Commissioning checks and data collection requirements of equipment and systems / plant to be described during Operation at various power levels

29.2.3.3.10 **MAINTENANCE, INSPECTION AND TESTING**

Surveillance, pre-service and in-service inspections, maintenance and testing requirements are to be included. General approach and guidelines based on recommendations of equipment / component supplier and I.S.I. programme are to be given. Down-time for each activity is also to be included.

29.2.3.3.11 **RADIOLOGICAL ASPECTS**

System/equipment radiation fields / activity / accessibility during normal reactor operation and shutdown are to be included. Shielding and sealing provided / required for accessibility during operation, shutdown and maintenance are to be described.

29.2.3.3.12 **POSTULATED FAILURES**

Should include system reliability, single/dual failures, fault sequence analysis and consequences of failure. Mitigation of radiological consequences is also to be described.

29.2.3.3.13 **TECHNICAL SPECIFICATIONS**

Technical specifications for operation of the system with basis are to be described.

29.2.3.3.14 **DIFFERENCES WITH EARLIER PLANT/STATION**

Differences of the system with earlier plant/station giving reason for changes are to be described.

29.2.3.3.15 **TABLES**

Include following applicable tables.

(i) Thermal data
(ii) Flow data
(iii) Pressure data
(iv) Level data
(v) Inventory data
(vi) Motorised valve positions
(vii) System instrumentation data
(viii) System electrical loads data
(ix) Chemical control specification for fluids
(x) Normal operation, alarm and trip parameters
(xi) Equipment, control hand switch, location, etc.

(xii) Window annunciation & COIS inputs.

29.2.3.3.16 **REFERENCES**

Include the following applicable references:-

(i) Design basis reports
(ii) Design manuals
(iii) Analyses and experimental reports
(iv) Published literature
(v) Specifications
(vi) Drawings
(vii) Documents

29.2.3.3.17 **EQUIPMENT/COMPONENT DATA**

For each equipment and component, include:-

(i) Purchase order number
(ii) Supplier's name and location
(iii) Cost
(iv) Specifications
(v) Examination and testing requirements
(vi) List of spare parts
(vii) Miniature drawing
(viii) Drawings and documents list

29.2.3.3.18 **ENCLOSURES**

(i) Figures
(ii) Graphs
(iii) Miniature flow sheets/schematics

29.2.3.4 **DETAILS OF TOPICS TO BE INCLUDED IN DESIGN MANUAL FOR BUILDING & CIVIL STRUCTURES**

29.2.3.4.1 **INTRODUCTION**

Describe the function of building and structure in the reactor / plant.

29.2.3.4.2 **DESCRIPTION**

Give description which should also include location and principle dimensions of the building and structure. Include sketches where necessary.

29.2.3.4.3 **CLASSIFICATION**

Safety/seismic classification, fire rating, etc. and design bases for foundations and superstructures, protection against hazards.

29.2.3.4.4 **DESIGN APPROACH**

Give applicable codes and standards, material specifications, loads and load combinations.

29.2.3.4.5 **ANALYSES**

Static and dynamic analysis method, description of mathematical models, summary of analysis result.

29.2.3.4.6 **TESTING**

Give testing requirements if any, acceptance criteria etc. to be followed.

29.2.3.4.7 **MAINTENANCE AND INSPECTION**

Surveillance, pre-service and in-service inspections, maintenance and testing requirements, if any, are to be included.

29.2.3.4.8 **DIFFERENCE WITH EARLIER PLANT/STATION**

Difference of the building / structure with earlier plant/station building / structure are to be described giving reasons for changes.

29.2.3.4.9 **REFERENCE**

Include the following applicable references :

(i) Design basis reports
(ii) Design manuals
(iii) Analyses and experimental reports
(iv) Published literature
(v) Specifications
(vi) Drawings
(vii) Documents

29.2.3.4.10 **ENCLOSURES**

Drawings / sketches.

29.2.4 **Design Calculations**

29.2.4.1 Design calculations are performed to arrive at final parameters and sizing of systems, structures, equipment, components.

29.2.4.2 In certain specific cases, the calculations done may have multiple utility and required to be part of more than one document. In such cases it would be preferable to prepare the design calculations as separate design document and refer it by its distinctive number in various Documents instead of repeating the design calculations in these documents.

When the calculations are exclusively done for or required only for a specific design document e.g. Design Basis Report or Safety Analysis Report or Design Manual etc., such calculations can be part of that document.

29.2.4.3 The design calculations are done on the basis of input data available from sources like Analysis, Study Reports, Research & Development Reports, Design Basis Report, Codes, Standards and Computer Software as applicable. The authenticity of the input data shall be ensured and references recorded. Assumptions made shall be noted. While indicating the reference number of applicable Codes, Standards etc. in the design calculations, the Edition Number/Year of Publication of Codes, Standards etc. must be indicated.

When the calculations are made using computer programs, sample hand calculations would be made (to the extent possible) to ensure reasonableness of the output. Computer programmes used in calculation should be validated prior to its use.

29.2.4.4 It should be ensured that following design aspects have been considered in the design calculations

i) Adequacy and reasonableness of assumptions made.

iii) Proper identification of codes, standards, formulae, equations, correlations and acceptance criteria.

iv) Appropriate design methods.

v) Results compatible with input and expectations.

29.2.5 All drawings as called for in other sections of this specification shall be submitted.

29.2.6 Specifications for all system, structures and equipments covered in this specification shall be submitted.

29.3 **Procurement, Manufacture, Erection / Construction -** For all bought out items the final copies of purchase recommendation & purchase orders shall be submitted to PURCHASER.

For all system, structures & components all final approved quality plans, vendor drawings, shop test reports, History docket including but not limited to the following:

a) Design documents including design specification as called for by design codes all calculation and design concession requests approved by PURCHASER. Final design report as called for by design codes.
b) Approved quality plan
c) As built drawings
d) Certified material test reports
e) Heat treatment records.
f) All NDT documents/records.
g) All test reports.
h) Copies of all POs & shipping releases.

Collection and documentation of pre service inspection data of UT inspection of all weld joints in safety related parts of high energy piping.

Collection and documentation of UT thickness gauging data of all vulnerable locations as called for in this specification, for continuous monitoring of all

high energy piping for entire system, for flow accelerated corrosion.

29.4 **Commissioning & testing, Trial operation** - For all system, structures & components -commissioning procedures, commissioning reports, operation and maintenance manuals, operating procedures & operating flow-sheets. Maintenance procedures. All data recorded at various power levels up to 100% full power operation.

29.5 Both soft copies and hard copies shall be submitted for all the documents. Soft copy of final documents shall be submitted in editable in MS word as well as non editable soft copies in pdf form.

29.6 Format for submission of the documents & drawings will be given to successful bidder.

29.7 All the documents & drawings shall be checked, reviewed, and approved by appropriate level of engineers. All the documents and drawings submitted to purchaser shall be signed by engineer preparing, checking, reviewing and approving the document or drawing. Same engineer can not perform two activities i.e. preparing, checking, reviewing and approving.

29.8 CONTENTS OF HISTORY DOCKET: History docket shall contain the following

1. Index.
2. Purchase order including amendments if any.
3. Shipping releases.
4. Technical specifications of all items of system, structure and components.
5. List of as built drawings.
6. Quality assurance plan, manufacturing process plans & list of manufacturing drawings.
7. All manufacturing procedures such as heat treatment, non–destructive examination, tests, painting, packing, storage, preservation procedures etc.
8. Raw material identification reports.
9. Test certificates of material including consumables.
10. Welding procedure specifications and performance qualification records.
11. Non – destructive examination reports.
12. Heat treatment reports (Time temp. charts).
13. Hydrostatic / pneumatic test results.
14. Helium leak test results.
15. Performance test, routine acceptance test and type test reports.
16. Record of dimensions / inspection report.
17. Pre-service base line information report.
18. Design concession requests (DCR).
19. Guarantee certificate / certificate of compliance.

20. Executive summary of non-conformance & rectification reports.

29.9 Contents of Operation and maintenance manual

Generally Operation and maintenance manual include following particulars and other details as applicable.

i) Index.
ii) Description of system/equipment/component.
iii) List of applicable drawings, specifications, data sheets
iv) Catalogue of bought out (off the shelf) items.
v) Special tools and tackles, if any, with full particulars including drawings
vi) Installation, calibration, pre commissioning and commissioning procedures.
vii) Operation and operating procedures including limiting conditions and restrictions on off-design operation.
viii) Assembly / dis-assembly procedures.
ix) Overhauling procedures and checks, if any.
x) Maintenance procedures.
xi) Recommended periodicity of maintenance, operating life and shelf life of replacement parts.
xii) Recommended inventory of spare parts.
xiii) Handling / storage instruction including monitoring during storage.
xiv) Condition monitoring and trouble shooting.
xv) All the industrial safety measures required for working on or near high temperature system , piping and equipment wherever applicable.

Submission of standard catalogues giving details of all models in Operation and maintenance manual is not acceptable. CONTRACTOR shall specifically explain the details of type of model selected in manual with all the relevant details.

29.10 Format for preparation of all type of drawings, lists, schedules will be given to successful bidders. Similarly CONTRACTOR shall indicate the PURCHASER's tag numbering system for all equipment, piping, valves, instrumentation items, cables as per PURCHASER's numbering system. These tag numbers shall be indicated along with the CONTRACTOR's tag numbers on all drawings and documents.

The list of sub-vendors acceptable to the PURCHASER for major equipment / services is enclosed in this section. **Although number of sub-vendors has been listed, CONTRACTOR shall themselves ascertain the present technical and financial capability of the suppliers for the supply of items prior to placement of PO to sub-vendors.** In case of any difficulty, the CONTRACTOR can also propose alternate sub-vendors with documentary evidence and proper justification for review and approval by PURCHASER. In such cases, the CONTRACTOR shall evaluate these vendors with respect to their technical and financial capabilities, order booking position, adhering to delivery schedule etc. and submit the report to PURCHASER for review and approval. It shall be CONTRACTOR'S responsibility to **ascertain the present technical and financial capability of the sub vendors listed in this section for the supply of items prior to placement of PO to sub-vendors.** It shall be CONTRACTOR'S responsibility to ensure that the vendor selected implements the quality assurance programme in line with PURCHASER's quality assurance programme and meeting the requirements of tender specification. CONTRACTOR shall note that there shall not be any price implication in the event of PURCHASER not approving the alternate sub-vendors suggested by them and the contractor having to restrict his choices within PURCHASER provided sub-vendor list given in this section.

LIST OF SUGGESTED SUB-VENDORS FOR TURBINE ISLAND PACKAGE

Sr. No.	Item /Equipment / Package Detail	Supplier / Contractor name (Indian Vendor)	Supplier / Contractor address	Supplier / Contractor name (Foreign Vendor)	Supplier / Contractor address
A	**MECHANICAL ITEMS**				
1	HP TURBINE CASING CASTINGS	1. M/S. STAR WIRE INDIA LTD	BALLABHGARH	1. M/S. CHINA NATIONAL ERZHONG GROUP CO.	CHINA
				2. M/S. DALIAN HEAVY INDUSTRIES STEEL CASTING CO. LTD.	CHINA
				3. M/S. DOOSAN HEAVY INDUSTRIES	SOUTH KOREA
				4. M/S. JAPAN CASTING AND FORGING CORPORATION (JCFC)	JAPAN

				5. M/S. VOEST ALPINE LINZ	AUSTRIA
2	HP/LP ROTOR SHAFT FORGINGS			1. M/S. A. FINKL & SONS	USA
				2. M/S. BUDERUS EDELSTAHLWERKE GMBH	GERMANY
				3. M/S. CHINA FIRST HEAVY INDUSTRY	CHINA
				4. M/S. DOOSAN IMGB	ROMANIA
				5. M/S. DOOSAN HEAVY INDUSTRIES	SOUTH KOREA
				6. M/S. ENERGOMASHSPETSSTAL	UKRAINE
				7. M/S. FOMAS S.P.A.	ITALY
				8. M/S. FORGE MONCHIERI	ITALY
				9. M/S. JAPAN CASTING AND FORGING CORPORATION (JCFC)	JAPAN
				10.M/S. JAPAN STEEL WORKS (JSW)	JAPAN
				11.M/S. SAARSCHMIEDE GMBH	GERMANY
				12.M/S. SCHMIEDEWERKE GRODITZ GMBH	GERMANY
				13.M/S. SHEFFIELD FOREGEMASTERS ENGINNERING (SFEL)	UNITED KINGDOM
				14. M/S. SOCIETA DELLE FUNCINE	ITALY
3	GENERATOR ROTOR SHAFT FORGING			1. M/S. CHINA FIRST HEAVY INDUSTRIES	CHINA
				2. M/S. SAARSCHMIEDE	GERMANY
				3. M/S. JAPAN CASTING & FORGING CORPORATION	JAPAN
				4. M/S. BUDERUS EDELSTHAL	GERMANY
				5. M/S. SOCIETA DELLE FUNCINE	ITALY
				6. M/S. SUMITOMO CORPORATION	JAPAN
4	GENERATOR RETAINING RING FORGING			1. M/S. SAARSCHMIEDE, GMBH	GERMANY
				2. M/S. ENERGIETECHNIK	GERMANY
				3. M/S. SUMITOMO CORPORATION	JAPAN
				4. M/S. AUBERT & DUVAL	FRANCE

5	LUBE OIL PURIFICATIO N UNIT	1. M/S. VATS FILTERATION TECHNOLOGIES, PUNE	PUNE	1. M/S PALL FILTERATION	USA
		2. M/S. ALFA LAVAL	PUNE	2. M/S. FACET	SPAIN
6	CLADDED PLATES OF MSR & CONDENSER	1. IDL EXPLOSIVES LTD	HYDERABAD	1. M/S. METAL ONE CORPORATION	JAPAN
				2. M/S. VOESTALPINE	AUSTRIA
				3. M/S. HANWHA CORPN.	KOREA
				4. M/S. KOBE STEEL LTD.	JAPAN
				5. M/S. MARUBENI ITOCHO STEEL INC.	JAPAN
				6. M/S. ASAHI-KASEI	JAPAN
				7. M/S. JAPAN STEEL WORKS (JSW)	JAPAN
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7	HP-MSR- LP (CRH, HRH PIPES.)	1. M/S. BEND JOINT PVT. LTD.	BHOPAL		
		2. M/S. GUJRAT INFRA PIPES	VADODARA		
		3. M/S. UNITECH MACHINES LTD	SAHARANPUR		
		4. M/S. DEE DEVELOPMENT (INDIA)	PALWAL		
		5. M/S. STEWARTS AND LLOYD OF INDIA LTD	KOLKATA		
8	CONDENSER VACUUM PUMPS			1. M/S. GARDNER DENVER NASH MACHINERY	CHINA
				2. EDWARD	UK
9	LUBE OIL PUMPS (AUXILIARY OIL PUMPS AND EMERGENCY OIL PUMPS)	1. M/S. MATHER AND PLATT PUMPS LTD.	PUNE	1. M/S. COLFAX-ALLWEILER	GERMANY
		2. M/S. KIRLOSKAR BORTHERS LTD.	PUNE	2. M/S. RUTCHI	FRANCE
10	SEAL OIL PUMP	1. M/S. TUSHACO PUMPS	DAMAN	1. M/S. ALLWEILER	GERMANY
		2. M/S. UT PUMPS & SYSTEMS	FARIDABAD		
11	PRIMARY WATER PUMP	1. M/S. KSB PUMPS	PUNE		

		2. M/S. SULZER PUMPS	INDIA		
12	JACKING OIL PUMP			1. M/S. HYDAC FILTERCHNIK, GMBH	GERMANY
				2. M/S. BOSCH REXROTH	GERMANY
13	LUBE OIL PURIFICATIO N UNIT	1. M/S. VATS FILTERATION TECHNOLOGIES, PUNE	PUNE	1. M/S PALL FILTERATION	USA
		2. M/S. ALFA LAVAL	PUNE	2. M/S. FACET, SPAIN	SPAIN
				3. M/S. KAYDON	USA
14	MAIN OIL TANK AND TURBINE OIL STORAGE TANK	1. M/S. GLOBAL HEAVY ENGINEERING, BHOPAL	BHOPAL		
		2. M/S. PAL ENGG., CORPORATION, YAMUNAGAR	YAMUNAGAR		
		3. M/S. SHREE KUSHAL FABRICATORS, BHOPAL	BHOPAL		
		4. M/S. STEEL CRAFT, YAMUNAGAR	YAMUNAGAR		
		5. M/S. STEEL INNOVATIONS PVT., LTD., BHOPAL	BHOPAL		
		6. M/S. DENSER INDUSTRIES, NAGPUR	NAGPUR		
15	ENGINEERIN G CONSULTAN TS	1. M/S. DCPL	KOLKATA		
		2. M/S. TCE	MUMBAI		
16	CIVIL CONSTRUCTI ON AGENCIES	1. M/S. LARSEN & TOUBRO	MUMBAI		
		2. M/S. HINDUSTAN CONSTRUCTION CO.	MUMBAI		
		3. M/S. GAMMON INDIA LTD.	MUMBAI		
		4. M/S. SIMPLEX INFRASTRUCTURES LTD.			
		5. M/S. AFCONS INFRASTRUCTURES			

		LTD.			
		6. M/S SHAPOORJI PALLONJI	MUMBAI		
		7. M/S BRIDGE & ROOF	KOLKATA		
		8. M/S GANNON DUNKERLEY & CO.	KOLKATA		
		9. M/S INDU PROJECTS LTD.	HYDERABAD		
		10. M/S PETRON CIVIL ENGG. PVT. LTD.	MUMBAI		
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17	SEAMLESS PIPES (CS, AS AND SS)	1. M/S. MSL, RAIGAD	RAIGAD	1. M/S S.C. PETROTUB	ROMANIA
		2. M/S. ISMT, PUNE	PUNE	2. M/S DALMINE	ITALY
		3. M/S REMI METALS GUJARAT LTD., MUMBAI	MUMBAI	3. M/S VALLOUREC AND M/S MANNESMANN THYSSENKRUPP	GERMANY
		4. M/S. JINDAL STEEL TUBES	KOLKATA	4. M/S PRODUCTOS TUBULARES	SPAIN
		5. M/S. ZENITH STEEL TUBES	MUMBAI	5. M/S WYMMAN GORDON	USA
		6. M/S. RATNAMANI METALS AND TUBES LTD	AHMEDABAD	6. M/S SUMITOMO CORP.	JAPAN
		7. M/S. NFC	HYDERABAD	7. M/S TUBOS REUMIDIS	SPAIN
		8. M/S. SURAJ LIMITED.	AHMEDABAD	8. M/S COMMERCIALE TUBI ACCIAIO SPA.	ITALY
				9. M/S. AB SANDVIK	SWEDEN
				10. M/S. SALZGITTER MANNESMANN	FRANCE
				11. M/S. SCHOELLER BLACKMANN	AUSTRIA
				12. M/S. YANGZHOU CHENGDE STEEL PIPES CO., LTD.	CHINA
				13. M/S KASCO	SOUTH KOREA
18	WELDED PIPES (CS, AS)	1. M/S. MANN INDUS.	INDORE		
		2. M/S. DECCAN METAL INDUSTRIES, RAJPURA	PUNJAB		

		3. M/S. LALIT PIPES & PIPES LIMITED	KASARA		
		4. M/S. MSL	RAIGAD		
		5. M/S. RATNAMANI	AHMEDABAD		
19	SS TUBES	1. M/S. RATNAMANI	AHMEDABAD	1. M/S. FINE TUBES	UK
		2. M/S. NFC	HYDERABAD	2. M/S. VALLOUREC & MANNESMAN	GERMANY
		3. M/S. CST VALINOX	HYDERABAD		
		4. M/S REMI METALS GUJARAT LTD.	MUMBAI		
20	FORGED AND WELDED FITTINGS	1. M/S. DEE DEVELOPMENT	FARIDABAD	1. M/S. SUNGKWANG BEND CO.	SOUTH KOREA
		2. M/S. ARVIND METAL PIPES & FITTINGS	VADODARA	2. M/S. TECHTUBE	ITALY
		3. M/S. STEEL SAMRAT	TARAPUR	3. M/S. UNION PIPING	ITALY
		4. M/S. GUJARAT INFRA PIPES	VADODARA	4. M/S. ERNE	AUSTRIA
		5. M/S. MS FITTINGS	KOLKATA	5. M/S. PETROL RACCORDI	ITALY
		6. M/S. ECHAY INDUSTRIES, MUMBAI(FLANGES)	MUMBAI	6. M/S. M. E. G. A, SPA	ITALY
		7. M/S. PARAMOUNT FORGE, PANVEL, MAHARASHTRA (ONLY FOR FLANGES)	PANVEL, MAHARASHTRA	7. M/S BASSI LUIGI	ITALY
		8. M/S. HILTON METAL FORGINGS LTD	MUMBAI	8. M/S SCHULTZ	GERMANY
		9. M/S. STEWARDS & LLOYDS	CALCUTTA	9. M/S B.K.L. FITTINGS LTD	UK
		10. M/S. SWASTIK LLOYDS ENGINEERING PVT LTD	MUMBAI	10. M/S RACCORDI FORGEATI	ITALY
		11. M/S. TEEKAY TUBES	MUMBAI	11. M/S MYONG KWANG METAL CO.	SOUTH KOREA
		12. M/S. TRUE FAB PVT LTD.	FARIDABAD	12. M/S TEE KWANG	SOUTH KOREA

		13. M/S. S&G ENGINEERS PVT. LTD.	FARIDABAD	13. M/S FINO	GERMANY
		14. M/S. CHW FORGE PRIVATE LIMITED	HARYANA	14. M/S. JIANYIN LONGSHAN PIPE SOLUTION CO. LTD.	CHINA
		15. M/S. TECHNO PRODUCTS INDUSTRIES	GUJARAT		
21	PIPING FABRICATOR	1. M/S. GUJRAT INFRA PIPES	VADODARA	1. M/S. BASSI LUIGI, (SIMAS)	ITALY
		2. M/S. UNITECH MACHINES LTD	GURGAON		
		3. M/S. DEE DEVELOPMENT	FARIDABAD		
		4. M/S. BEND JOINTS	BHOPAL		
		5. M/S. PAL ENGG., CORPORATION	YAMUNAGAR		
		6. M/S. BHEL, TRICHY	TRICHY		
22	FILTER AND STRAINER	1. M/S. DRAYTON GREAVES	MUMBAI		
		2. M/S. JAYASHREE INDUSTRIES	HYDERABAD		
		3. M/S. MULTITEX	DELHI		
		4. M/S. PROCEDYNE ENGINEERS	CHENNAI		
		5. M/S. FILTERATION ENGINEERS	NAVI MUMBAI		
		6. M/S. GUJARAT OTOFILT	AHMEDABAD		
		7. M/S. FLASH POINT EQPMT. PVT. LTD.	PUNE		
		8. M/S. JAGTAP	VADODARA		
		9. M/S. SUPERFLOW	MUMBAI		
		10. M/S. HAWA VALVES	AHMEDABAD		
		11. M/S. KIRLOSKAR MAHALE FILTERS	PUNE		
		12. M/S. PAL ASSOCIATES	AHMEDABAD		
		13. M/S. PURELATOR	DELHI		

23	METALLIC EXPANSION BELLOWS	1. M/S. METALLIC BELLOWS	CHENNAI		
		2. M/S. FLEXICON BELLOWS	VADODARA		
		3. M/S. SUR INDUSTRIES	KOLKATA		
		4. M/S. FLEXTHERM EXPANSION BELLOW(P) LTD	VADODARA		
		5. M/S. LONESTAR	CHENNAI		
		6. M/S. PRECISION BELLOWS	AHMADABAD		
		7. M/S. FLUIDYNE ENGINEERS	CHENNAI		
24	HANGERS, SUPPORTS	1. M/S. BHEL	TRICHY		
		2. M/S. PIPE HANGERS AND SUPPORTS PVT., LTD.	CHENNAI		
		3. M/S. SARATHI ENGINEERING LTD	HYDERABAD		
		4. M/S. PIPING AND ENERGY PRODUCTS	DELHI		
		5. M/S. SPRING SUPPORTS MANUFACTURING CO.	KOLKATA		
25	FASTENERS	1. M/S. ALCO	HUBLI		
		2. M/S. BOLTMASTER	VASAI		
		3. M/S. GKW	MUMBAI		
		4. M/S. INDUSTRIAL FASTENERS	MUMBAI		
		5. M/S. MEGA ENGINEERING PVT. LTD			
		6. M/S. LAXMI PRECISION	MUMBAI		
		7. M/S. PRECISION ENGINEERING INDUSTRIES	VADODARA		
		8. M/S. PRECISION FASTENERS	MUMBAI		
		9. M/S. TVS SUNDARAM FASTENERS	CHENNAI		
		10. M/S. TCS	CHENNAI		

		11. M/S. UNBRAKO	MUMBAI		
		12. M/S. PRESIDENT ENGG. WORKS	MUMBAI		
		13. M/S. PIONEER NUTS AND BOLTS PVT. LTD.	LUDHIANA		
		14. M/S. INDUSTRIAL ENGG. CORPORATION	VASAI		
		15. M/S. INDCON	DELHI		
		16. M/S. SUMMITS HYGRONIC	COIMBATORE		
		17. M/S. MULTIFASTENERS	VADODARA		
26	GASKET	1. M.S. STARFLEX	GOA	1. M/S.FLEXITALLIC	UK
		2. M/S. IGP	CHENNAI		
		3. M/S. SG GASKET AND COOLING TOWER CO.	MUMBAI		
27	PLATES AND STRUCTURAL STEEL (CS & SS)	1. M/S. LLOYD STEEL	MUMBAI		
		2. M/S. RASHTRIYA ISPAT NIGAM LTD	VIZAG		
		3. M/S. SAIL	MUMBAI		
		4. M/S. TISCO	JAMSHEDPUR		
		5. M/S. JINDAL STEEL & POWER LTD.	ORISSA		
		6. M/S. ESSAR STEEL INDIA LTD.	HAZIRA		
28	STEAM TRAPS	1. M/S. SPIRAX MARSHALL	PUNE	1. M/S.GESTER GMBH	GERMANY
		2. M/S. PENNANT ENGG. PVT. LTD.	PUNE		
		3. M/S. FORBES MARSHALL	PUNE		
29	MANUAL VALVES GATE / GLOBE / CHECK VALVES AND MO VALVES (CAST STEEL /FORGED STEEL)	1. M/S. BHEL, TRICHY	TRICHY		
		2. M/S. L&T VALVES	CHENNAI		

		LIMITED			
		3. M/S. FOURESS ENGINEERING	AURANGABAD & BANGALORE PLANT		
		4. M/S. KIRLOSKAR BROTHERS LTD.	PUNE		
		5. M/S. KSB LTD	COIMBATORE		
		6. M/S. NICO SCHUBERT & SULZER LTD.	MUMBAI		
		7. M/S.PRECISION ENGINEERING CO. (ORNATE GROUP)	CHENNAI		
		8. M/S. LEADER VALVE	JALANDHAR		
		9. M/S. FORBES MARSHALL PVT. LTD.	PUNE		
		10. M/S. BDK	HUBLI		
		11. M/S. STEEL STRONG VALVES	MUMBAI		
		12. M/S SHRI CHAMUNDA VALVES PVT. LTD.	AHMEDABAD		
		13. M/S. PENTAIR VALVES AND CONTROLS INDIA PRIVATE LIMITED	BARODA		
		14. M/S. ADVANCE VALVES, NOIDA	NOIDA		
30	ANGLE GLOBE VALVE/ BLOWDOWN VALVES	1. M/S INDITECH VALVES PVT. LTD	PUNE		
		2. M/S. ASSOCIATED TOOLING	KOLKATA		
31	BALL VALVES	1. M/S. L&T VALVES LIMITED	CHENNAI	1. M/S. VANATOME	FRANCE
		2. M/S. MICROFINISH, (BDK)	HUBLI	2. M/S. PARKER	UK
		3. M/S. HYD AIR	MUMBAI	3. M/S. VELAN S.A.S.	FRANCE
		4. M/S. AKAY INDUSTRIES	HUBLI		
32	CONTROL VALVES	1. M/S. IL, PALAKKAD	PALAKKAD		
		2. M/S. R.K. CONTROLS	MUMBAI		
		3. M/S. MIL KSB CONTROLS LIMITED	PALAKKAD		
		4. M/S. VALFLOW,	AHMEDABAD		

		(M/S VALTEK)			
		5. M/S. SAMSONS CONTROL PVT., LTD.	THANE		
		6. M/S. FISHER SANMAR LIMITED	CHENNAI		
		7. M/S. FOURESS	BANGALORE		
		8. M/S. PENTAIR VALVES AND CONTROLS INDIA PRIVATE LIMITED	BARODA		
33	BUTTERFLY VALVES	1. M/S. L&T VALVES LIMITED	COIMBATORE		
		2. M/S. FISHER SANMAR	CHENNAI		
		3. M/S. FOURESS	BANGALORE		
		4. M/S. PENTAIR VALVES AND CONTROLS INDIA PRIVATE LIMITED	BARODA		
		5. M/S. INTERVALVE	PUNE		
		6. M/S. KBL	PUNE		
		7. M/S. CRANE PROCESS FLOW TECHNOLOGIES	PUNE		
		8. M/S. IL	PALGHAT		
34	DIAPHRAGM VALVES	1. M/S. BDK	HUBLI		
		2. M/S. CRANE PROCESS FLOW TECHNOLOGIES	PUNE		
		3. M/S. IL	PALGHAT		
		4. M/S. CHEM TECH VALVES	MUMBAI		
		5. M/S. ALFA LAVAL SAUNDERS	PUNE		
35	CHECK VALVES (WATER / AIR SERVICE) - TUBE VALVES			1. M/S. PARKER	UK
				2. M/S. SWAGELOK	USA
36	CHECK VALVES (OIL SERVICE)	1. M/S. BOSCH REXROTH	MUMBAI		
		2. M/S. VICKERS	MUMBAI		
37	AIR RELEASE VALVES	1. M/S. SPIRAX MARSHALL / M/S. FORBES MARSHALL	PUNE	1. M/S. ARMSTRONG INTERNATIONAL	UK

38	SAFETY RELIEF VALVES(WATER/AIR SERVICES)	1. M/S. BHEL	TRICHY	1. M/S. DRESSER CONSOLIDATED	USA
		2. M/S. TYCO SANMAR LTD	CHENNAI	2. M/S.WEIR VALVES	FRANCE
		3. M/S. MAZDA LTD.	AHMEDABAD		
		4. M/S. PENTAIR VALVES AND CONTROLS INDIA PRIVATE LIMITED	LIMITED		
		5. M/S. WEIR ENGG. SERVICES(I) LTD	INDIA		
		6. M/S. SEMPELL INDIA PVT. LTD.	PUNE		
		7. M/S. IL	PALGHAT		
		8. M/S. FAINGER LESSER VALVES (P) LTD.	PUNE		
39	RELIEF VALVES (OIL SERVICE)	1. M/S. BOSCH REXROTH	MUMBAI		
40	RELIEF VALVES (CROSS PORT) - WATER SERVICE			1. M/S. CIRCLESEAL	USA
41	RELIEF VALVES (TUBE END)			1. M/S. PARKER	UK
				2. M/S. SWAGELOK	USA
42	VACUUM RELIEF VALVES	1. M/S. NIRMAL INDUSTRIES	MUMBAI		
43	PRESSURE REDUCING VALVES(EXCEPT OIL SERVICE)	1. M/S. DEWARANEE MCNCIL	CALCUTTA	1. M/S. CONCOA	USA
		2. M/S. INDIAN OXYGEN LTD.	MUMBAI		
		3. M/S. MAZDA LTD	AHMEDABAD		
		4. M/S. BALDOTA VALVES & FITTINGS	MUMBAI		
		5. M/S. J N MARSHALL	PUNE		

		6. M/S. NIRMAL INDUSTRIES	MUMBAI		
44	PRESSURE REDUCING VALVES (OIL SERVICE)	1. M/S. BOSCH REXROTH	MUMBAI		
45	FLOW CONTROL VALVES (OIL SERVICE)	1. M/S. BOSCH REXROTH	MUMBAI	1. M/S. PARKER	UK
46	MSIV (MAIN STEAM ISOLATION	1. M/S. FORBES MARSHALL PVT. LTD.	PUNE	1. M/S. HOPKINSONS LTD.	UK
				2. M/S. VELAN SA	FRANCE
				3. M/S. CCI SULZER	SWITZERL AND
				4. M/S. SEMPELL	GERMANY
47	MAIN STEAM RELIEF VALVES			1. M/S. WEIR POWER & INDUSTRIAL	FRANCE
				2. M/S. CCI SULZER VALVES	GERMANY
48	ATMOSPHERIC STEAM DISCHARGE VALVE (ASDV) AND CONDENSER STEAM DUMP VALVE (CSDV)	1. M/S.KSB MIL CONTROLS LIMITED		1. M/S. CCI SULZER	GERMANY
		2. M/S. IL, PALGHAT (INSTRUMENTATIO N LTD.)	PALGHAT	2. M/S. WEIR POWER AND INDUSTRIAL	FRANCE
				3. M/S. DANFOSS SOCIA	ITALY
49	BOILER FEED PUMPS	1. M/S. KSB	PUNE	1. M/S. CLYDE UNION	UK
		2. M/S. FLOWSERVE INDIA	CHENNAI	2. M/S. TERMOMECCANICA POMPE (TMP)	ITALY
				3. M/S. KSB	GERMANY
50	AUXILIARY BFP	1. M/S. KSB	PUNE	1. M/S. TERMOMECCANICA POMPE (TMP)	ITALY
		2. M/S. KBL (KIRLOSKAR EBARA	PUNE		

		PUMPS)			
		3. M/S. FLOWSERVE INDIA	CHENNAI		
51	FEED WATER HEATERS	1. M/S. BHEL	BHOPAL		
		2. M/S. L & T	MUMBAI		
		3. M/S. HPVP	VIZAG		
		4. M/S. GODREJ	MUMBAI		
		5. M/S. ISGEC	YAMUNANAGAR		
52	DEAERATOR AND STORAGE TANK	1. M/S. BHEL	TRICHY		
		2. M/S. HPVP	VIZAG		
		3. M/S. L & T	HAZIRA		
		4. M/S. GEA ENERGY (M/S. BGR)	CHENNAI		
53	TANKS & PRESSURE VESSELS	1. M/S. HPVP	VIZAG		
		2. M/S. GANSONS LTD.	NAGPUR		
		3. M/S. GODREJ & BOYCE	MUMBAI		
		4. M/S. IAEC INDIA LTD	CHENNAI		
		5. M/S. ISGEC	YAMUNANAGAR		
		6. M/S. L & T	MUMBAI		
		7. M/S. LLOYD STEEL	MUMBAI		
		8. M/S. NATIONAL HEAVY ENGINEERING CORPORATION LTD.	PUNE		
		9. M/S. RAJ ENGINEERING CO.	MUMBAI		
		10. M/S. SAURASHTRA ENGINEERING	MUMBAI		
		11. M/S. SHAKTI HI TECH.	CHENNAI		
		12. M/S. VIVIDH HI-FAB	BARODA		
		13. M/S. WIL	WALCHANDNAGAR		
		14. M/S. ANUP ENGG CO.	AHMEDABAD		
		15. M/S. GEA BGR	CHENNAI		

		ENERGY			
		16. M/S. NEW AGE FAB. TECH. PVT. (FABTECH) LTD.	SURAT		
		17. M/s. INDUSTRIAL EQUIPMENT PVT. LTD.	SHIL PHATA, THANE		
		18. M/S. ISHAN EQUIPMENTS PVT. LTD.	VADODARA		
54	HEAT EXCHANGERS (Shell and tube type)	1. M/S. GODREJ & BOYCE	MUMBAI		
		2. M/S. BHEL	TRICHY		
		3. M/S. HPVP	VIZAG		
		4. M/S. GR ENGINEERING	MUMBAI		
		5. M/S. L&T	MUMBAI		
		6. M/S. ISGEC	YAMUNANAGAR		
		7. M/S. WIL	WALCHANDNAGAR		
		8. M/S. LAXMI ENGINEERING INDUSTRIES (BHOPAL) PVT. LTD.	BHOPAL		
		9. M/S. NEW AGE FAB. TECH. PVT. (FABTECH)LTD.	SURAT		
55	PLATE TYPE HEAT EXCHANGERS	1. M/S. ALFA - LAVAL	PUNE		
		2. M/S. IDMC	ANAND		
		3. M/S. APV	CALCUTTA		
		4. M/S. GEA ECOFLEX INDIA PVT. LIMITED	PUNE		
	-	5. TRANTER	PUNE		
	-	6. KELVION INDIA PVT. LTD	PUNE		
56	CENTRIFUGAL PUMPS	1. M/S. AKAY INDUSTRIES	HUBLI	1. M/S. WEIR PUMPS	UK
		2. M/S. BPCL	NAINI		
		3. M/S. KBL	PUNE		
		4. M/S. SULZER PUMPS LTD	NAVI MUMBAI		
		5. M/S. KSB	PUNE		
		6. M/S. MATHER & PLATT	PUNE		

		7. M/S. WORTHINGTON	CALCUTTA		
57	SUBMERSIBLE PUMPS FOR NON ACTIVE DRAINAGE SYSTEM.	1. M/S. KBL	PUNE		
		2. M/S. KISHOR PUMP	PUNE		
		3. M/S. SU PUMP	MUMBAI		
		4. M/S. MBH PUMPS (GUJ.) PVT. LTD.	AHMEDABAD		
		5. M/S. DARLING PUMP	INDORE		
58	POSITIVE DISPLACEMENT PUMPS	1. M/S. ROTO PUMPS	DELHI		
		2. M/S. UT PUMPS AND SYSTEMS PVT. LTD.	FARIDABAD		
59	RUBBER EXPANSION JOINTS	1. M/S. APHRODITE POLYPRENE PVT. LTD. (APPL)	KOLKATA		
		2. M/S. CORI	CHENNAI		
		3. M/S. D. WREN	KOLKATA		
60	ORIFICE PLATE ASSEMBLIES	1. M/S. TEMP TECH	MUMBAI		
		2. M/S. MINCO	GOA		
		3. M/S. IL	PALGHAT		
		4. M/S. STAR MECH	PUNE		
		5. M/S. SGPE	AMBERNATH		
		6. M/S. DYNAFLUID VALVES AND FLOW CONTROLS PVT. LTD.	BELGAUM		
		7. M/S. HYDROPNEUMATICS PVT. LTD.	GOA		
		8. M/S. VINIR ENGG PVT.LTD	BANGALORE		
		9. M/S. M G M FORGING	HUBLI		
61	AIR CONDITIONING & VENTILLATION	1. M/S. BLUE STAR LTD.	MUMBAI		
		2. M/S. ANDREW	KOLKATA		

		YULE LTD.			
		3. M/S. LLOYDS LTD.	DELHI		
		4. M/S. AVPL	KUNDLI, HARYANA		
62	CHEMICAL DOSING SYSTEM	1. M/S. ION EXCHANGE (INDIA) LTD.	NAVI MUMBAI		
		2. M/S. THERMAX LIMITED	PUNE		
		3. M/S. POSITIVE METERING PUMPS (I) PVT LTD	NASHIK		
63	SGBD POLISHING UNITS.	1. M/S. ION EXCHANGE (INDIA) LTD.	NAVI MUMBAI		
		2. M/S. THERMAX LIMITED.	PUNE		
		3. M/S. DRIPLEX WATER ENGINEERING INTERNATIONAL LIMITED.	DELHI		
		4. M/S. DOSHION	AHMEDABAD		
64	CRANES & HOISTS	1. M/S. WMF CRANES LTD	MUMBAI		
		2. M/S. FURNACE AND FOUNDRY ENGG. CO. LTD.	MUMBAI		
		3. M/S UNIQUE INDUSTRIAL HANDLER PVT. LTD.	MUMBAI		
		4. M/S MUKAND LTD.	MUMBAI		
		5. M/S ELECTROMECH MATERIAL HANDLING SYSTEMS (I) LTD.	PUNE		
		6. M/S. ANUPAM INDUSTRIES LTD.	ANAND, GUJARAT		
		7. M/S. SAFEX INDUSTRIES LTD.	AHMEDABAD.		
		8. M/S. BRADY AND MORRIS ENGG.	KHEDA, GUJARAT		
65	FIRE DETECTION AND	1. M/S. KIDDE	DELHI		

	SUPPRESSION SYSTEM				
		2. M/S. TECHNICO	KOLKATA		
		3. M/S. TYCO	MUMBAI		
		4. M/S. NEW FIRE CO.	MUMBAI		
		5. M/S. MATHER & PLATT (MPF SYSTEM)	MUMBAI		
		6. M/S. STERLING & WILSON	MUMBAI		
66	SNUBBERS AND SWAY BRACES			1. M/S. LESIGA	GERMANY
				2. M/S. CARPENTER AND PETTARSON	UK
				3. M/S. DAMAN JARRET	FRANCE
				4. M/S. NPS IBERICA	SPAIN
				5. M/S. PIPE SUPPORT SYSTEMS GMBH INTERNATIONAL	GERMANY
				6. M/S. QUIRI	FRANCE
				7. M/S. PACIFIC SCIENTIFIC	USA
B	**ELECTRICAL ITEMS**				
1	ISOLATED PHASE BUSDUCT (IPBD)	1. M/S. REEP INDUSTRIES	CHENNAI		
		2. M/S. C&S ELECTRIC	DELHI		
		3. M/S. BHEL	HARIDWAR		
2	GENERATOR CIRCUIT BREAKER (GCB)	1. M/S. ABB	MUMBAI	1. M/S. ALSTOM GRID SAS	FRANCE
		2. M/S. HITACHI	DELHI		
3	MCCS	1. M/S. SIEMENS	MUMBAI		
		2. M/S. L&T	MUMBAI		
		3. M/S. SCHNEIDER	AHMEDABAD		
4	ELEVATORS	1. M/S. OTIS	MUMBAI		
		2. M/S. KONE (OLYMPUS)	DELHI		
		3. M/S. TECHNO INDUSTRIES LTD	AHMEDABAD		
		4. M/S. SCHINDLER	NOIDA		
5	AC & DC	1. M/S. SIEMENS	MUMBAI		

	DBS				
		2. M/S. L&T	MUMBAI		
		3. M/S. SCHNEIDER	AHMEDABAD		
		4. M/S. C&S	NOIDA		
		5. M/S. GE POWER	NOIDA		
6	LV POWER (XLPE INSULATED FRLS PVC SHEATHED) CABLES	1. M/S. NICCO CABLES	KOLKATA		
		2. M/S. UNIVERSAL CABLES	SATNA		
		3. M/S. PARAMOUNT CABLE COORPORATION	DELHI		
		4. M/S. HAVELL'S INDIA	ALWAR		
		5. M/S.FINOLEX CABLES, URSE	PUNE		
		6. M/S. POLYCAB CABLES	DAMAN		
		7. M/S. UNI FLEX CABLES	GUJARAT		
		8. M/S. KEI	AHMEDABAD		
		9. M/S.TORRENT CABLES	AHMEDABAD		
		10. M/S. RAVIN CABLES, MARKAL	PUNE		
		11. M/S. RALLISON ELECTRICALS, CHOPANKI	BHIWADI		
7	CONTROL CABLES	1. M/S. NICCO CABLES	KOLKATTA		
		2. M/S. UNIVERSAL CABLES	SATNA		
		3. M/S. FINOLEX CABLES,URSE	PUNE		
		4. M/S. POLYCAB CABLES	DAMAN		
		5. M/S. UNI FLEX CABLES	GUJARAT		
		6. M/S. KEI	ALWAR		
		7. M/S.TORRENT CABLES	AHMEDABAD		

		8. M/S. RAVIN CABLES, MARKAL	PUNE		
		9. M/S. RADIANT CABLES	HYDERABAD		
8	FIRE BARRIER	1. M/S. SIGNUM (FOR BOTH INDOOR AND OUTDOOR)	NAGPUR		
		2. M/S. NAVAIR (FOR BOTH INDOOR AND OUTDOOR)	DELHI		
		3. M/S. MULTIKIL (FOR INDOOR ONLY)	VADODARA		
9	FIRE BREAKS	1. M/S. SIGNUM (FOR INDOOR ONLY)	NAGPUR		
		2. M/S. VIJAI FIRE (FOR BOTH INDOOR AND OUTDOOR)	MUMBAI		
10	CABLE TRAYS AND ACCESSOTIRS	1. M/S. ASIAN ANCILIARIES	MUMBAI		
		2. M/S. DOLPHIN ENGG	ANAKAPALLE, AP		
		3. M/S. INDIANA CABLE TRAYS	MUMBAI		
		4. M/S. METALLEMS	MUMBAI		
		5. M/S. TECHNOFAB	NASHIK		
		6. M/S. PATNY SYSTEMS	HYDERABAD		
11	LIGHTING FIXTURES	1. M/S. BAJAJ	MUMBAI		
		2. M/S. PHILLIPS	MUMBAI		
		3. M/S. CROMPTON GREAVES	MUMBAI		
		4. M/S. WIPRO	MUMBAI		
12	STRUCTURAL STEEL INCLUDING ROUNDS IS 2062 GRD A 40.000 MM	1. M/S. STEEL AUTHORITY OF INDIA LTD.	MUMBAI		
		2. M/S. RASHTRIYA ISPAT NIGAM LTD.	VIZAG		
		3. M/S. TATA STEEL LIMITED	MUMBAI		
13	LUGS	1. M/S. DOWELL	MUMBAI		
		2. M/S. 3D	KOLKATA		
		3. M/S. COMET	DELHI		

14	ANCHOR FASTENERS	1. M/S. HILTI	MUMBAI		
		2. M/S. ANCHOR	MUMBAI		
		3. M/S. DASH	DELHI		
		4. M/S. ARISTOCRAT	BANGALORE		
15	FLAME PROOF LIGHTING FIXTURES	1. M/S. BALIGA	CHENNAI		
		2. M/S. FLAME PROOF CONTROL GEAR	MUMBAI		
		3. M/S. PROMPT ENGINEERING WORKS	MUMBAI		
16	415 V MOTORS	1. M/S. KEC LTD.	BANGALORE		
	(GREATER THAN 50 KW)	2. M/S. CROMPTON GREAVES LTD.	MUMBAI		
		3. M/S. ABB LTD.	MUMBAI		
		4. M/S. SIEMENS LTD.	MUMBAI		
		5. M/S. BHARAT BIJLEE LTD.	MUMBAI		
		6. M/S. ALSTOM	MUMBAI		
17	415 V MOTORS	1. M/S. KEC LTD.	BANGALORE		
	(LESS THAN 50 KW)	2. M/S. CROMPTON GREAVES LTD.	MUMBAI		
		3. M/S. ABB LTD.	MUMBAI		
		4. M/S. SIEMENS LTD.	MUMBAI		
		5. M/S. BHARAT BIJLEE LTD.	MUMBAI		
		6. M/S. ALSTOM INDIA LTD.	MUMBAI		
		7. M/S. REMI UDYOG P. LTD (UP TO 30 KW ONLY FOR NON CRITICAL APPLICATIONS LIKE EXHAUST FANS FOR ROOMS, OFFICES, DEWATERING PUMPS AND DRIVE MOTORS FOR ISOLATORS……)	MUMBAI		
		8. M/S. LAXMI HYDRAULICS PVT. LTD.	SOLAPUR		

18	6.6 KV MOTORS	1. M/S. BHEL	BHOPAL		
		2. M/S. CROMPTON GREAVES LTD.	MUMBAI		
		3. M/S.ABB (UP TO 2000 KV) LTD.	MUMBAI		
		4. M/S.ALSTOM (UP TO 950 KV) INDIA LTD.	MUMBAI		
		5. M/S.KEC LTD.	BANGALORE		
19	TERMINAL BLOCKS	1. M/S. ELMEX CONTROLS P. LTD.	VADODARA		
		2. M/S. CONNECT WELL INDUSTRIES PVT. LTD.	DOMBIVALI		
20	HV FUSES IN IPBD			1. M/S. SADTEM	FRANCE
21	GI COATED EARTHING MATERIAL COMPRISING OF FOLLOWING:				
21a)	EARTHING FLAT GALVANIZED STEEL (GS FLAT)	1. M/S. RUKMANI ELECTRICALS & COMPONENT PVT.LTD.	KOLKATA		
		2. M/S. PREMIER POWER PRODUCT	KOLKATA		
21b)	EARTHING FLAT GALVANIZED IRON (GI FLAT)	1. M/S. RUKMANI ELECTRICALS & COMPONENT PVT.LTD.	KOLKATA		
		2.M/S. PREMIER POWER PRODUCT.	KOLKATA		
21c)	EARTHING ELECTRODES (MILD STEEL 40MM DIA 3.5M)	1. M/S. RUKMANI ELECTRICALS & COMPONENT PVT.LTD.	KOLKATA		
		2. M/S. PREMIER POWER PRODUCT.	KOLKATA		
21 d)	GI FLEXIBLE WIRE	1. M/S. P S ELECTRICAL	KOTA		
21 e)	FLEXIBLE GI CONDUIT	1. M/S. P S ELECTRICAL	KOTA		
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	-				
C	**CONTROL & INSTRUMENT**				

	ATION ITEMS				
	-				
1	SS TUBING	1. M/S. NUCLEAR FUEL COMPLEX, HYDERABAD.	Hyderabad	1.M/S SANDVIK, SWEDEN	Sweden
		2. M/S. RATNAMANI METALS & TUBES LTD.	Ahmedabad	2.M/s.Finetubes UK	UK
		3. M/S REMI Edelstahl Tubular Limited	Mumbai		
2	SS PIPE and SS PIPE FITTINGS	1. M/S. NUCLEAR FUEL COMPLEX, HYDERABAD	Hyderabad		
		2. M/S ARVIND PIPES AND FITTINGS IND. PVT. LTD., MUMBAI	Mumbai		
		3. M/S. CHOKSI TUBE CO. LTD.			
		4. M/S COMMERCIAL SUPPLYING AGENCY, MUMBAI	Mumbai		
		5. M/S. EBY FASTENERS,TALOJA	Taloja		
		6. M/S. CENTRAL STEEL CORPORATION , MUMBAI	Mumbai		
3	CS PIPE	1. M/S ARVIND PIPES AND FITTINGS IND. PVT. LTD., MUMBAI	Mumbai		
		2. M/S. INDIAN SEAMLESS LTD.			
		3. M/S. HYDAIR ENGG WORKDS, MUMBAI	Mumbai		
		4. M/S. CENTRAL STEEL CORPORATION , MUMBAI	Mumbai		
		5. M/S.LLOYD ENGG PVT LTD , NAVI MUMBAI	Mumbai		
4	CS PIPE FITTINGS	1. M/S ARVIND PIPES AND FITTINGS IND. PVT. LTD., MUMBAI	Mumbai		
		2. M/S. EBY FASTENERS, MUMBAI	Mumbai		
		3. HYDAIR MUMBAI	, Mumbai		
		4. CENTRAL STEEL CORPORATION , MUMBAI	Mumbai		
		5. LLOYD ENGG PVT LTD , NAVI MUMBAI	Mumbai		

5	ADAPTORS	1. M/S ASTEC VALVES & FITTINGS PVT. LTD.	Mumbai.		
		2. M/S EXEL HYDRO PNEUMATIC, MUMBAI	Mumbai		
		3. M/S. TEMPTECH, MUMBAI	Mumbai		
6	COPPER TUBING	1. M/S MULTIMETALS, KOTA	Kota		
		2. M/S RAJCO METAL INDUSTRIES PVT. LTD., MUMBAI	Mumbai		
		3. NATIONAL METAL MUMBAI	Mumbai		
		4. M/S.HINDUSTAN STEEL & METAL WORKS, MUMBAI	Mumbai		
7	SS TUBE FITTINGS			1.M/S SWAGELOK CO., USA	USA
				2.M/s. PARKER HANNIFIN U.K.	UK
				3.M/S.CREXIMCO, USA	USA
8	BRASS TUBE FITTINGS	1. M/S.FLUID TECH, MUMBAI	Mumbai	1. M/s. HERION AND NORGEN ,	
		2. M/S ASCO INDIA LTD, CHENNAI	Chennai	2. M/s. HAHN& SOUR ,	
		3. M/S.V.R.ENGINEERING, MUMBAI	Mumbai	3. M/s. VICKERS , UK	UK
		4. PRICISION INDUSTRIES MUMBAI	Mumbai		
		5. M/S.SAMTA WELDING WORKS			
		6. M/S.MULTIMETAL, BARODA	Ba, Roda		
		7. M/S HYD-AIR ENGG. WORKS, MUMBAI	Mumbai		
9	AIR ACCUMULATOR TANKS	1. M/S. DCMS ENGG. CO. MUMBAI.	Mumbai		
		2. M/S NATIONAL ENGG. CO., BARODA	Mumbai		
10	CATCH POTS	1. M/S. DCMS ENGG. CO. MUMBAI.	Mumbai		
		2. M/S COLDWELD ENGINEERS PVT. LTD			
11	BRASS PIPE FITTINGS	1. M/S ASTEC VALVES & FITTINGS PVT. LTD.	Mumbai		
		2. M/S EXEL HYDRO PNEUMATIC, MUMBAI	Mumbai		
		3. M/S. FLUIDCONTROLS			

12	BRASS CHECK VALVES	1. M/S HYD-AIR ENGG. WORKS, MUMBAI	Mumbai		
		2. M/S ASTEC VALVES & FITTINGS PVT. LTD	Mumbai		
		3. M/S EXEL HYDRO PNEUMATIC, MUMBAI	Mumbai		
		4. M/S.ANMOL FLUID CONNECTORS, MUMBAI	Mumbai		
13	AIR FILTER PRESSURE REGULATORS	1. M/S SHAVONORGREN INDIA PVT. LTD., MUMBAI	Mumbai		
		2. M/S PLACKA INST			
		3. M/S. SMC PNEUMATICS, NOIDA. /CHENNAI	Mumbai		
14	SS ISOLATION NEEDLE VALVES	1. M/S HYD-AIR ENGG. WORKS, MUMBAI	Mumbai	1. M/S. SWAGELOK CO., USA	USA
		2. M/S ASTEC VALVES & FITTINGS PVT. LTD.	Mumbai	2.M/s. PARKER HANNIFIN U.K.	UK
		3. M/S. CHEMTROL ENGINEERING, MUMBAI.	Mumbai		
		4. M/S. FLUID CONTROLS MUMBAI	Mumbai		
		5. M/S. PANAM ENGINEERS LIMITED, MUMBAI	Mumbai		
		6. Excel Hydro Pneumatic	Mumbai		
15	1/2" C.S. VALVES	1. M/S. BDK LEADER		1. M/S. SWAGELOK CO. U.S.A.	USA
		2. M/S. R.K.ENGG MUMBAI	Mumbai		
		3. M/S HYD-AIR ENGG. WORKS, MUMBAI	Mumbai		
		4. M/S ASTEC VALVES & FITTINGS PVT. LTD.	Mumbai		
		5. M/S.PROTOLINA INSTRUMENTS, MUMBAI	Mumbai		
		6. M/S.FOURESS			
16	PACKED SS 3 VALVE MANIFOLDS	1. M/S. HYD-AIR ENGG. WORKS, MUMBAI	Mumbai	1. M/S. SWAGELOK CO. U.S.A.	USA
		2. M/S ASTEC VALVES & FITTINGS PVT. LTD.	Mumbai	2.M/s. PARKER HANNIFIN U.K.	
		3. M/S. EXCEL HYDRO MUMBAI	Mumbai		
		4. M/S.PANAM ENGINEERS LIMITED,	Mumbai		

		MUMBAI			
17	PACKED 5 VALVE MANIFOLDS FOR HIGH PRESSURE & HIGH TEMP. APPLICATION	1. M/s.Hyd-air Engineering Works, Mumbai	Mumbai	1. M/S. PARKER HANNIFIN CORP. U.K.	UK
		2. M/S ASTEC VALVES & FITTINGS PVT. LTD.	Mumbai	3.M/S. SWAGELOK CO. U.S.A.	USA
		3. M/s.Placa Instruments, Chennai	Chennai	4.M/S. THOMSON VALVES, U.K.	UK
		4. M/s. Panam Engineers Limited, Mumbai.	Mumbai	5.M/S.ANDERSON GREENWOOD, U.K.	UK
18	BRASS NEEDLE VALVES	1. M/S HYD-AIR ENGG. WORKS, MUMBAI	Mumbai		
		2. M/S ASTEC VALVES & FITTINGS PVT. LTD.	Mumbai		
		3. M/S. EXCEL HYDRO MUMBAI	Mumbai		
		4. M/S. R.K.CONTROLS INSTR., THANE	Mumbai		
19	SS BOURDON TUBE PRESSURE GAUGES	1. M/S. BAUMER TECHNOLOGIES INDIA PVT LTD		1. M/S. ASHCROFT, U.K.	UK
		2. M/S. PRECISION INSTRUMENTS, MUMBAI.	Mumbai		
		3. M/S. GAUGES BOURDON (INDIA) PVT. LTD.			
		4. M/S. A.N.INSTRUMENTS, KOLKATA.	Mumbai		
		5. M/S. H. GURU (PG & DP), KOLKATA	Mumbai		
		6. M/S.SWITZER (DGP), CHENNAI	Chennai		
		7. M/S.PRICOL, CHENNAI	Chennai,		
20	DIFFERENTIAL PRESSURE GAUGES	1. M/S. BAUMER TECHNOLOGIES INDIA PVT LTD		1. M/S. ASHCROFT, U.K.	UK
		2. M/S. PRECISION INSTRUMENTS, MUMBAI.	Mumbai		
		3. M/S. GENERAL INSTRUMENTS, MUMBAI.	Mumbai		
		4. M/S. A.N.INSTRUMENTS,	Mumbai		

		KOLKATA.			
		5. M/S. H. GURU (PG & DP), KOLKATA	Mumbai		
		6. M/S. SWITZER (DGP), CHENNAI	Chennai		
		7. M/S. PRICOL, CHENNAI	Chennai		
21	TEMPERATURE GAUGES	1. M/S. BAUMER TECHNOLOGIES INDIA PVT LTD			
		2. M/S . BELLS CONTROLS, MUMBAI.	Mumbai		
		3. M/S. GENERAL INSTRUMENTS, MUMBAI.	Mumbai		
		4. M/S. A.N.INSTRUMENTS, KOLKATA.	Mumbai		
		5. M/S.H. GURU (PG & DP), KOLKATA	Mumbai		
		6. M/S.PRICOL, CHENNAIMUMBAI	Chennai, Mumbai		
22	LEVEL GAUGES	1. M/S. PUNE TECHTROL, PUNE	Pune	M/s K	
		2. M/S . CHEMTROL ENGG. LTD., MUMBAI	Mumbai		
		3. M/S. ASIAN INDUSTIAL VALVES & INSTRUMENTS, CHENNAI	Chennai		
		4. M/S. K-TECH ,ING - ENGG CO. (MAGNETIC)			
		5. M/S. WIKA PUNE (MAGNETIC)	Pune		
		6. M/S. CRYSTAL INSTRUMENTS, MUMBAI	Mumbai		
		7. M/S. LEVCON INSTRUMENTS, KOLKATA	Kolkata		
23	PRESSURE SWITCHES & DP SWITCHES	1. M/S SWITZER INSTR LTD., CHENNAI,	Chennai,	1.M/s.DWYER INSTRUMENTS, U.K.	UK
		2. M/S. PRECISION IINDUSTRIES, MUMBAI. (FOR ASHCROFT MAKE)		2.M/s. ASHCROFT, U.K.	UK
		3. M/S.INDFOSS		3.M/s. SOR, USA	USA
		4. M/S.SWITZER (DPG), CHENNAI	Chennai	4.M/s.KDG, MOBREY, UK	UK
		5. M/S. VERMA TRAFAG.		5.M/s. ASCO, USA	USA
24	TEMPERATURE SWITCHES	1. M/S GOA INSTRUMENTS CONSORTIUM,	Mumbai		

		MUMBAI			
		2. M/S. SWITZER			
25	FLOW SWITCHES	1. M/S. KROHNE MARSHAL LTD., PUNE.	Mumbai		
		2. M/S. INSTRUMENTATION ENGRS., HYDERABAD	Mumbai		
		3. M/S GENERAL INSTS MUMBAI.	Mumbai.		
26	LIMIT SWITCHES	1. M/S BHARTIYA CUTLER & HAMMER , MUMBAI / CHENNAI	Chennai	1. M/s. MICROSWITCH USA	USA
		2. M/S.KAYCEE INDUSTRIES		2. M/s.HONEY WELL, USA	USA
		3. M/S.JAIBALAJI, CHENNAI	Chennai	3. M/s. SNAPLOC, USA	USA
27	LEVEL SWITCHES	1. M/S. TRANSDUCERS & CONTROL PVT. LTD., HYDERABAD	Hyderabad	1. M/S. KDG MOBREY U.K.	UK
		2. M/S. CHEMTROL ENGG.LTD.,MUMBAI	Mumbai		
		3. M/S. SBEM PUNE	Pune		
		4. M/S. SWITZER (DPG) CHENNAI	Chennai		
		5. M/S. D.K. INSTRUMENTS, KOLKATA	Mumbai		
		6. M/S. LEVCON INSTRUMENTS, KOLKATA	Kolkata		
		7. M/S. V. AUTOMAT	Delhi		
28	ELECTRONIC TRANSMITTERS	1. M/s. Baldota Controls & Equipments Pvt. Ltd., Mumbai (for SMAR MAKE)	MUMBAI	1. M/S SMAR, BRAZIL	
		2. M/S. ABB LIMITED, HARYANA	HARYANA	2. M/s ABB	JAPAN
				3. M/s Seimens, Germany	
		3. M/S. EMERSON, BARODA	BARODA		
		4. M/S. HONEYWELL, GURGAON	GURGAON	4. M/s HONEYWELL	
		5. M/S. ENDRESS + HAUSER (INDIA) PVT. LTD. , MUMBAI	MUMBAI	5. Endress & Hauser	
		6. M/s YOKOGAWA INDIA	MUMBAI	6. M/S. YOKOGAWA	
29	TEMP. TRANSMITTERS	1. M/S. MASIBUS PROCESS INST. GANDHINAGAR.	Gandhinagar.	1. M/S. YOKOGAWA	
		2. M/S.Astron Mumbai	Mumbai	2. M/s PR Electronics, Denmark	
		3. M/S. Emerson Process (I) Ltd. .	Mumbai		
		4. M/s ABB	Bhopal		

30	E/A CONVERTER	1. M/S SHREYAS INST. PVT. LTD., CHENNAI	Chennai	1. M/s YOKOGAWA	
		2. M/S. Emerson Process (I) Ltd. (for FISHER make) .			
		3. M/s Fairchild	Mumbai		
31	ELECTO-PNEUMATIC Converter		Mumbai		
32	RTDs	1. M/S. TEMP TECH, MUMBAI	Mumbai	M/s Ericat, France	
		2. M/S. GEN. INSTRUMENTS CONSORTIUM, MUMBAI.(GEN PURPOSE) / CHENNAI	Mumbai	M/s CMR, France	
		3. M/S. TEMPSENS UDAIPUR	Udaipur		
		4. M/S. IL, KOTA	Kota		
		5. M/S. DETRIV, MUMBAI	Mumbai		
		6. M/s ABB	Hariyana		
		7. M/s Emerson	Vadodara		
		8. M/s Endress & Hauser	Mumbai		
33	THERMOCOUPLES	1. M/S. TEMP TECH, MUMBAI	Mumbai	M/s Ericat, France	
		2. M/S. GEN. INSTRUMENT CONSORTIUM, MUMBAI / CHENNAI	Mumbai	M/s CMR, France	
		3. M/S TEMPSENS UDAIPUR	Udaipur		
		4. M/S. DETRIV, MUMBAI	Mumbai		
		5. M/S. IL, KOTA	Kota		
		6. M/s ABB	Hariyana		
		7. M/s Emerson	Vadodara		
		8. M/s Endress & Hauser	Mumbai		
34	JUNCTION BOXES & ACCESSORIES	1. M/S PYROTECH, UDAIPUR	Udaipur		
		2. M/S RELIABLE ELECTRICALS, MUMBAI.	Mumbai		
		3. M/S.INDUSTRIAL CONTROLS AND APPLIANCES, MUMBAI	Mumbai		
		4. M/S. ECIL, HYDERABAD	Hyderabad		
		5. M/S.JAISON-HUTCHISON, CHENNAI	Chennai		
		6. M/S.I.L., KOTA	Kota		
		7. M/S.BALIGA, CHENNAI	Chennai		

		9. M/S. RITTAL, BANGALORE	BANGALORE		
		10. M/S. BCH ELECTRIC, FARIDABAD	FARIDABAD		
		11. M/S. EMECON OCNTROLS PTVT. LTD., NEW DELHI	DELHI		
		12. M/S. EXPROTECTA, BARODA	BARODA		
		13. M/S. VISHWKARAMA, NEW DELHI	NEW DELHI		
35	TB & ACCESSORIES	1. M/S. CONNECTWELL MUMBAI.	Mumbai		
		2. M/S. PHOENIX INDIA NOIDA	Noida		
		3. M/S. WEIDMULLER INDIA BANGLORE.	Mumbai		
		4. M/S. ELMEX CONTROLS PVT. LTD., BARODA	Mumbai		
36	VIBRATION MONITORING SYSTEM FOR HT DRIVES	1. M/s. Meggit India Private Limited		1.M/S SCHENCK, GERMANY	GERMANY
		2. M/s. FORBES MARSHAL, PUNE	Pune	2.M/S.BENTLY NEVADA, GE USA	USA
		3. IRD Mechanalysis Limited	Mumbai	3.M/S SHINKAWA, JAPAN	JAPAN
37	H2 LEAK DETECTION SYSTEM	1. M/S . SUBTRONICS, MUMBAI	Mumbai	1. M/s. FIGARO JAPAN	JAPAN
		2. M/S. JB BODA B'lore	B'lore	2.M/s. BIELER +LANG GERMANY	GERMANY
		3. M/s. Ambetronics Engineers Pvt. Ltd., Mumbai	Mumbai		
		4 M/s Uniphos Envirotronic Pvt Ltd.	Umbergaon, Dist Valsad		
38	FEED WATER QUALITY ANLYZAR. (SWAS)	1. M/S. EMERSON PROCESS, MUMBAI	MUMBAI	1. M/s Meltor Toledo, USA	
				2. M/s Endress and Hauser, Germany	
		2. M/s. FORBES MARSHAL, PUNE	Pune	3. M/s Teledyne, USA	
		3. M/S. ORBIT TECHNOLOGY (SWAN, SWITZERLAND MAKE), HYDERABAD	HYDERABAD	4. M/s Hach, USA	
		4. M/s Steam Equipment Pvt. Ltd.	Pune		

39	SOLENOID VALVE	1. M/S. IL KOTA	Kota	1. M/s. VALCOR, U.S.A	USA
		2. M/s. ASCO,Chennai	Chennai	2.M/s. Segault, France	FRANCE
		3. M/s. Rotex, Vadodara	Vadodara		
40	LOCAL CONTROL PANELS (FLOOR MOUNTED TYPE)	1. M/S. INDUSTRIAL CONTROL & APPLIANCES, MUMBAI.	Mumbai		
		2. M/S KEAS CONTROLS , COIMBATORE	Coimbatore		
		3. M/S. RELIABLE ELECTRICALS MUMBAI	Mumbai		
		4. M/S. IL., KOTA	Mumbai		
		5. M/S.PYROTECH, UDAIPUR	Udaipu, R		
		6. M/S. ECIL, HYDERABAD	Hyderabad		
		7. M/S.KAIREL SWITCHGEAR	Switchgea		
		8. M/S.ELEC-MECH, MUMBAI	Mumbi		
		9. M/S.JAISON-HUTCHISON, CHENNAI	Chennai		
		10. M/S.SHIBSHAW INSTRUMENTS, CHENNAI	Chennai		
		11. M/S.PRAMAN INDUSTRIES, PUDUKOTAI (TAMIL NADU)	Pudukotai (Tamilnadu)		
41	HANDSWITCHES (PANEL MOUNTED COMPONENTS)	1. M/S KAYCEE, MUMBAI	Mumbai		
		2. M/S SEIMENS, MUMBAI	Mumbai		
		3. M/S. SALZER,COIMBATORE	Coimbatore		
		4. M/S. MOSS MAN(ENTECH)			
		5. M/S.LARSEN & TOUBRO			
42	PUSH BUTTONS	1. M/S BHARTIYA CUTLER HAMMER			
	(PANEL MOUNTED COMPONENTS)	2. M/S SEIMENS, MUMBAI	Mumbai		
		3. M/S. CONCORD, MUMBAI	Mumbai		
		4. M/S. TECHNIC, MUMBAI	Mumbai		

		5. M/S.CUTLER-HAMMER			
		6. M/S.KAYCEE			
		7. M/S.SALZER			
		8. M/S.BALIGA, CHENNAI	Chennai		
43	INDICATING METERS	1. M/S LEKTROLAB, MUMBAI	Mumbai		
	(PANEL MOUNTED COMPONENTS)	2. M/S MECO INSTRUMENTS, MUMBAI	Mumbai		
		3. M/s.ELECTRONET (LOOP POWERED)			
		4. M/S.TELETHERM, CHENNAI	Chennai		
		5. M/S.LECTROLAB, MUMBAI	Mumbai		
44	ANNUNCIATORS	1. M/S. APLAB, MUMBAI	Mumbai		
	(PANEL MOUNTED COMPONENTS)	2. M/S. IL, KOTA	Kota		
		3. M/S. ECIL, HYDERABAD	Hyderabad		
		4. M/S. INTELEC, PUNE	Pune		
		5. M/S. INSTA ALARM MUMBAI	Mumbai		
		6. M/S.TELETHERM, CHENNAI	Chennai		
		7. M/S. LECTROLAB, MUMBAI	Mumbai		
45	TERMINAL BLOCKS	1. M/S ELMEX, BARODA	Baroda	1. M/S WEID MULLAR, GERMANY	GERMANY
	(PANEL MOUNTED COMPONENTS)	2. M/S. CONNECT WELLS (DOMBIVLI), MUMBAI	Mumbai		
		3. M/S. PHOENIX INDIA	New Delhi		
46	RELAYS	1. M/S. PLA		1. M/s. KUNKE GERMANY	GERMANY
	(PANEL MOUNTED COMPONENTS)	2. M/S. LARSEN & TOUBRO			
		3. M/S. OEN			
		4. M/S. SIEMENS			
		5. M/s. ITI B'LORE	B'lore		
		6. M/s. OMRON			
		7. M/s. JYOTI INDUSTRIES BARODA	Baroda		
		8. M/s.	India		

		TELEMECHANIQUE (INDIA)			
47	LAMPS (CLUSTERED LED)	1. M/S. CONCORD		1. M/s. AGASTAT USA	USA
	(PANEL MOUNTED COMPONENTS)	2. M/S. SIEMENS			
		3. M/S. LARSEN & TOURBO			
		4. M/S. BHARATIYA CUTLER & HAMMER			
		5. M/S. ASEA, BANGALORE	Bangalore		
		6. M/s. TELEMECHANIQUE INDIA	India		
		7. M/s. OMRON			
		8. M/s. ECIL			
48	FUSES	1. M/S. LARSEN & TOUBRO			
	(PANEL MOUNTED COMPONENTS)	2. M/S. SIEMENS			
		3. M/s. GE POWER			
		4. M/s.BUSSMAN			
49	MCB	1. M/s INDO KOPP			
	(PANEL MOUNTED COMPONENTS)	2. M/s LEGRANDE (FORMERLY M/s MDS)			
		3. M/s.SEIMENS			
50	AVERAGING PITOT TUBES (ANNUBARS)	1. M/S. SWITZER, CHENNAI	Chennai		
		2. M/S. CHANDAK INSTRUMENTS, NAGPUR (FOR M/S.VERIS INC.USA MAKE)	Mumbai		
		3. M/s.Emerson process			
		4. M/S.FISHER ROSEMOUNT / M/S.DIETRICH	Mumbai		
51	PAPER LESS DIGITAL RECORDERS	1. M/s. CHINO LAXONS			
		2. M/s. EUROTHERM(DEL INDIA)	India		
52	ORIFICE PLATE ASSEMBLIES	1. M/s. IL-PALGHAT	Palghat		
		2. M/S. MINCO, GOA	Goa		

		3. M/S. TEMP TECH, MUMBAI	Mumbai		
		4. M/s. STARMECH, PUNE	Pune		
		5. M/s. SGPE, AMBERNATH	Ambernath		
		6. M/s. MICROPRECISION			
		7. M/s. GENERAL INSTRUMENTS, MUMBAI	Mumbai		
53	FLOW GLASSES	1. M/S.LEVCON, KOLKATA	Kolkata		
		2. M/S.PRATOLINA, MUMBAI	Mumba		
		3. M/s. ASIAN INDUSTRIES CHENNAI	Chennai		
		4. M/s. TRAC			
54	ULTRASONIC FLOW INSTRUMENTS	1. M/s.KHRONE MARSHAL		1.M/s.Thermo scientific USA	USA
		2. M/s. PANAMETRICS	Mumbai	2. M/s.Panametrics, U.S.A.	USA
				3. M/s. CONTROTRON	
		3. M/s. ELECTRONET PUNE (ABM CANADA)	Pune	4. M/S. POLISONIC, USA	USA
		4. M/s. E&H(I)			
		5. M/s.THERMO FISHER SCIENTIFIC NAVI MUMBAI	Mumbai		
		6. M/S. IOTAFLOW Systems Pvt. Ltd., New Delhi	Mumbai		
		7. M/S. THOSBRO, MUMBAI	MUMBAI		
		8. M/S. WAREE INSTRUMENTS, MUMBAI	MUMBAI		
		9. Adept Fluidyne	Pune		
		10. EIP Enviro, Noida (BM Tecnologie, Italy)	Noida		
55	MAGNETIC Level Guage with Transmitter / Switch and Level Guage	1. M/s. MAGNETROL	Mumbai		
		2. M/s. KTEK MUMBAI	Mumbai		
		3. M/s.WIKA PUNE (MAGNETIC)	PUNE		
		4. M/s. V.Automat & Instruments Pvt. Ltd., New Delhi	Mumbai		
		5. M/S. WEKA, (FORBES MARSHAL) PUNE	PUNE		

56	ULTRASONIC LEVEL INSTRUMENTS	1. M/s. SBEM PUNE	Pune		
		2. M/s. KTEK MUMBAI	Mumbai		
		3. M/s.PUNE TECHTROL (PUNE)	Pune		
		4. M/S. ELECTRONET , PUNE	PUNE		
		5. M/S. E & H (I), AURANGABAD	AURANGABAD		
		6. M/S. NEVELCO, MUMBAI	MUMBAI		
57	CAPACATIVE TYPE LEVEL INSTRUMENTS	1. M/s. SBEM PUNE	Pune		
		2. M/s. KTEK MUMBAI	Mumbai		
		3. M/s. PUNE TECHTROL (PUNE)	Pune		
58	ANALYTICAL INSTURMENTS	1. M/s. METLER TOLADO			
		2. M/s. POLYMETRON			
		3. M/s.ORBIT TECHNOLOGIES , HYDERABAD	Hyderabad		
		4. M/s.BECKMAN			
59	TURBINE METERS	1. M/s. ROCKWIN FLOW METERS , GAZIABAD	Gaziabad		
60	VORTEX FLOW METERS	1. M/s. KHRONE MARSHAL			
		2. M/s. PEPL UDAIPUR	Udaipur		
61	CONDUCTIVITY METERS/LEVEL PROBE/TRANSMITTERS	1. M/S. TECHNO INSTRUMENTS		1. M/s. LEVEL STATE USA	USA
		2. M/S. JINDAL ELECTRONICS		2. M/s. SOLOTRON MOBREY	
		3. M/S. EMERSON, BARODA	BARODA	3. M/S. JUMO, GERMANY	GERMANY
		4. M/S. ENDRESS & HAUSER, BARODA	BARODA	4. M/S. THERMO SENSOR, GMBH	GERMANY
		5. M/S. ABB, FARIDABAD	FARIDABAD		
		6. M/S. FORBES MARSHALL, PUNE	PUNE		
		7. M/S. HONEWELL, GURGAON	GURGAON		
62	UNINTERRUPTIBLE POWER SUPPLY (UPS) 240 VAC INVERTERS	1. M/S HI-REL ELECTRONICS PVT. LTD. AHMEDABAD	Ahmedabad		

		2. M/S TATA LIEBERT, MUMBAI-EMERSON			
		3. M/S KELTRON, TRIVANDRAM	Trivandram		
		4. M/S. ADOR-POWERTRON LIMITED, PUNE.	Pune.		
		5. M/S Consul Neowatt	Pune		
63	LEAD ACID BATTERIES	1. M/S. EXIDE, KOLKATA	KOLKATA		
		2. M/S. BUI, PUNE	PUNE		
64	BATTERY CHARGERS	1. M/S HBL NIFE POWER SYSTEMS LTD., HYDERABAD			
		2. M/S. CALDYNE, KOLKATA	KOLKATA		
		3. M/S. KELTRON, TRIVANDRAM	Trivandram		
		4. M/S. CHABBI ELECTRICALS PVT., LTD., JALGAON	JALGAON		
		5. M/S. MASSTECH CONTROL PVT., LTD., JALGAON	JALGAON		
65	Venturi & Flow Nozzle Assemblies	1. M/s. Temp Tech, Mumbai	Mumbai		
		2. M/s. Minco, Goa	Nashik		
		3. M/s. SGPE, Ambarnath	Ambarnathhth		
		4. M/s. Vividh Hi Feb, Vadodara	Vadodara		
		5. M/s. IL, Palghat	Palgtat		
		6. M/s. Microprecision			
		7. M/s. Hydropneumatic	Goa		
		8. M/s. General Instruments, Consortium, Chennai	Chennai		
		9. M/s. DynaFluid Valves and Flow Controls Pvt.Ltd.	Hubli		
		10. M/s. MSID	Gwalior		
66	Purge Rotameters with DP regulator	1. M/s. Transducers and Controls Ltd., Hyderabad	Hyderabad		
		2. M/s. Rockwin Flow Meter India Pvt. Ltd. Gaziabad	Gaziabad		
67	Density Gauges	1. M/s. Transducers & Control Ltd., Hyderabad	Hyderabad		
		2. M/s. Eureka Industries, Pune	Pune		
68	Metal Tube Rotameter with transmitter with	1. M/s. Transducers & Control Ltd., Hyderabad	Hyderabad		

	(4-20 mA DC)				
		2. M/s. Khrone Marshall, Pune	Pune		
69	Metal Tube Rotameters	1. M/s. Transducers & Control Ltd., Hyderabad	Hyderabad		
		2. M/s. Eureka Industries, Pune	Pune		
		3. M/s. IEPL, Hyderabad	Hyderabaddad		
70	Glass Tube Rotameters	1. M/s. Transducers & Control Ltd., Hyderabad	Hyderabad		
		2. M/s. Eureka Industries, Pune	Pune		
		3. M/s. IEPL, Hyderabad	Hyderabaddad		
71	Sight Glass Indicators	1. M/s. Crystal Instrument, Mumbai	Mumbai		
		2. M/s. Pune Techtrols, Pune	Pune		
		3. M/s. Asean instuments, Chennai	Chen chennai, chennai		
72	Paddle Type Flow Switches	1. M/s. Switzer, Chennai	Nashik		
		2. M/s.General Instruments Consortium, Mumbai	Mumbai		
73	Temperature Gauge with Thermowell (Bi metal type)	1. M/s. Goa Instruments, Goa	Goa		
		2. M/s.Baumer Technologies India Pvt Ltd			
		3. M/s.Forbes Marshall, Hyderabad	Hyderabad		
		4. M/s..H. Guru, Bangaluru	Nashik		
		5. M/s. A.N. Instruments, Kolkata	Nashik		
74	Temperature Gauge with Thermowell (Gas filled)	1. M/s. Goa Instruments, Goa	Goa		
		2. M/s. Baumer Technologies India Pvt Ltd			
		3. M/s. Forbes Marshall, Hyderabad	Hyderabad		
		4. M/s. H. Guru, Bangaluru	Nashik		
		5. M/s. A.N. Instruments, Kolkata	Nashik		
		6. M/s. WIKA	Pune		
75	Float and Tape type level indicating switches	1. M/s. SBEM Pvt. Ltd., Pune	Pune	1. M/S. KDG MOBREY, UK	UK

		2. M/s. K Tek, Mumbai	Nashik		
		3. M/s. Pune Techtrol, Pune	Pune		
		4. M/s. Nivo Controls Pvt. Ltd., Indore	Indore		
		1. M/S. LEVCON INSTRUMENTS PVT. LTD.,KOLKATA	KOLKATA		
		2. M/S. TRANSDUCERS & CONTROL PVT., LTD., HYDERABAD	HYDERABAD		
		3. M/S. CHEMTROLS ENGG., LTD, MUMBAI	MUMBAI		
76	Electric Actuators	1. M/s. Auma – India	Nashik	1. M/s. Auma – Germany	GERMANY
		2. M/s. Rotork, India	Nashik	2. M/s. Rotork, UK	UK
77	Air Filter Regulator	1. M/s. Shavo Norgen, Bangalore	Bangalore		
78	Needle Valves	1. M/S ASTEC VALVES & FITTINGS PVT. LTD.	Mumbai	1.M/s.Swagelok,USA	USA
		2. M/s. Fluid Control Pvt. Ltd, Mumbai	Mumbai	2.M/s. Parker, UK	UK
		3. M/s. Veljan Hyd Air, Mumbai	Mumbai		
		4. M/s. Leader Engineering	Nashik		
		5. M/s. Excelsior Engg.			
79	Needle Valves (Tube Ends) - Water Service			1.M/s.Swagelok,USA	USA
				2.M/s. Parker, UK	UK
80	Plug valves(with soft sleeve)	1. M/s. Xomox Sanmar,Chennai	Chennai		
81	Pressure Reducing Valves(Except oil service)	1. M/s. Dewaranee Mcncil, Calcutta	Calcutta	1. M/s. Concoa,USA	USA
		2. M/s. Indian Oxygen Ltd., Mumbai	Mumbai		
		3. M/s. Mazda Ltd, Ahmedabad	Ahmedabad		
		4. M/s. Baldota valves & Fittings, Mumbai	Mumbai		
		5. M/s. J N Marshall, Pune	Nashik		
		6. M/s. Hyd Air Engineering, Mumbai	Mumbai		
		7. M/s. Schrader-Scovill Duncan			
		8. M/s. Shavo Norgren, Mumbai	Mumbai		
		9. M/s. Veljin Hydair			
		10. M/s. Masoneilene, Mala, Kerala	Kerala		
		11. M/s. Jay Industries			

82	Pressure Reducing Valves (Oil Service)	1. M/s.Bosch Rexroth, Mumbai	Mumbai		
83	Flow Control Valves (Oil Service)	1. M/s. Bosch Rexroth, Mumbai	Mumbai	1. M/s.Parker, UK	UK
84	Special Valves e.g. Excess Flow Check valves, Differential Pressure Reducing valves, Rotary Directional Valves, etc.	1. M/s.L&T Valves Limited	Coimbatore	1. M/s. Barksdale, USA	USA
		2. M/s. MTAR, Hyderabad	Hyderadad		
		3. M/s. Nirmal Industries, Mumbai	Mumbai		
		4. M/s. Piping and Energy Products, New Delhi	New Delhi		
85	NITROGEN BLANKETING SYSTEM	1. M/s. Nirmal Industries, Mumbai	Mumbai		
86	Gas Manifold (Oxygen, Helium, CO2)	1. M/s. Indian Oxygen Ltd., Mumbai	Mumbai		
		2. M/s. Baldota valves & Fittings, Mumbai	Mumbai		
		3. M/s. Nirmal Industries, Mumbai	Mumbai		
87	Leakage Indicating Gauges (LIGs)	1. M/s. Asian Industrial valves & instruments, Chennai	Chennai		
		2. M/s. Crystal industrial Syndicate, Mumbai	Mumbai		
88	FIGs (Flow Indicating Gauges)	1. M/s. Asian Industrial Valves & Instruments, Chennai	Chennai		
		2. M/s. Sigma Industries, Mumbai	Mumbai		
		3. M/s. Suhag Process, Mumbai	Mumbai		
		4. M/s. Transducers & Controls, Hyderabad	Hyderabad		
89	Leakage Metering Device (LMDs)	1. M/s. Jayashree Industries, Hyderabad	Hyderabad		
90	Ejectors	1. M/s.Mazda Engineering, Ahmedabad	Ahmedabad		
		2. M/s. New Field Industrial Eqpt. Co. Baroda	Baroda		
91	Seal Leakage	1. M/s. Jayashree	Hyderabad		

	Measuring Device	Industries, Hyderabad			
92	Pipe section mounted Ultrasonic flow meter (WATER)	1. M/s. Khrone Marshall, Pune	Pune	1.M/s. Panametrics, U.S.A.	USA
		2. M/s. Thermo Fisher Scientific Navi Mumbai	Navi Mumbai		
93	Pipe to tube adaptors	1. M/s.Temp Tech, Mumbai	Mumbai		
		2. M/S ASTEC VALVES & FITTINGS PVT. LTD.	Vasai		
		3. M/s. Exel Hydro, Mumbai	Mumbai		
94	EPR Insulated Instrument Cables.	1. M/s.Apar Industries Limited			
		2. M/s.Reliance Engineers,			
		3. M/s.CMI Ltd. Delhi,	Nashik		
		4. M/s.Delton Cables,			
		5. M/s.Brooks, Mumbai,	Nashik		
		6. M/s.Suyog Electricals Ltd., Baroda	Baroda		
		7. M/s.Omega Cables, Chennai	Chennai		
		8. M/s. Thermo Cables Ltd.			
95	Control Cables	9. M/s. Urja Cables, Bhopal	Bhopal		
		10. M/s. Fixolite, nasik	Nashik		
		11. M/s.Apar Industries Limited	Limited		
		12. M/s. Reliance Engineers,	Nashik		
		13. M/s. CMI Ltd. Delhi,	Nashik		
		14. M/s. Delton Cables,	Nashik		
		15. M/s. Brooks, Mumbai,	Nashik		
		16. M/s. Finolex	Finolex		
		17. M/s. Asian	Asian		
		18. M/s. Fort Closter	Nashik		
		19. M/s. CCI	Cci		
		20. M/s. INCAB	Incab		
		21. M/S. PARAMOUNT COMMUNICATION, NEW DELHI	NEW DELHI		
		22. M/S. ELKAY TELELINDS LTD,. FARIDABAD			

		23. M/S. R.J. INDSUTRIAL CORPORATION, ROORKEE	ROORKEE		
		24. M/S. UNIVERSAL CABLES LTD., SATANA	SATANA		
		25. M/S SERVEL INDIA PVT LTD	DELHI		
		26. M/S. KE INDSUTRIES LTD,.NEWDELHI	NEW DELHI		
96	Cone Flow Meter	1. M/s. Hydropneumatics Pvt. Ltd., Goa.	Goa.		
97	Supply of Lab Instruments (Test & Calibration Facility)	1. M/s. WIKA Instruments Pvt. Ltd., Pune	Pune		
		2. M/s. Isothermal Technology Pvt. Ltd., Delhi.	Delhi.		
		3. M/s. Fluke Technologies Pvt. Ltd.	Mumbai		
98	Reverse Rotation Switch / probe			1.M/S SCHENCK, GERMANY	GERMANY
		2. M/s. Meggit India Private Limited		2.M/S.BENTLY NEVADA, GE USA	USA
		3. M/s. FORBES MARSHAL, PUNE	Pune	3.M/S SHINKAWA, JAPAN	JAPAN
		4. IRD Mechanalysis Limited	Mumbai		
99	Air manifold	1. M/s Coldweld Engineers pvt ltd	Bhiwandi		
100	GWR TYPE LEVEL TRANSMITTER	1. M/S. ABB INSTRUMENTS (K-TEK), FARIDABAD/ MUMBAI	MUMBAI	1. M/S. M/S. MAGNETROL, BELGUM	BELGIUM
		2. EIP Enviro, Noida (BM Tecnologie, Italy)	Noida	2. M/S. EMERSON, GERMANY	GERMANY
				3. M/S. ENDRESS & HAUSER, GERMANY	GERMANY
				4. M/S. VEGA, GERMANY	GERMANY
101	VIBRATING FORK TYPE LEVEL SWITCH	1. M/S. ENDRESS & HAUSER, AURANGABAD	AURANGABAD	1. M/S. VEGA, GERMANY	GERMANY
		2. M/S. EMERSON, BARODA	BARODA		
		3. M/S. SBEM, PUNE	PUNE		
		4. M/S. PUNE TECHTROL, PUNE	PUNE		
		5. M/S. BAUMER TECHNOLOGY (PEVIOUSLY WAREE), MUMBAI	MUMBAI		
		6. M/S. WIKA, PUNE	PUNE		

		7. M/S. SAPCON, INDORE	INDORE		
102	THERMAL MASS FLOW METER	1. M/S. FCI, NAGPUR	NAGPUR	1. M/S. MAGNETROL,	BELGIUM
				2. M/S. ENDRESS & HAUSER, GERMANY	GERMANY
				3. M/S. FCI, USA	USA
				4. M/S. SAGE, USA	USA
				5. M/S. KURZ, USA	USA
103	MASTER CLOCK SYSTEM	1. M/S. SERTEL, CHENNAI	CHENNAI		
		2. M/S. SANDS, CHENNAI	CHENNAI		
		3. M/S. MASIBUS, GANDHI NAGAR	GANDHI NAGAR		
104	H2 GAS ANALYSER CABINET	1. M/S. ABB LTD.,			
		2. M/S. YOKOGAWA BLAE STAR			
		3. M/S. HONEY WELL AUTOMATION			
		4. M/S. CHEMTROLS			
		5. M/S. SIEMENS			
		6. M/S. ADAGE AUTOMATION PVT., LTD.,			
105	TURBINE SUPERVISORY SYSTEM	1. M/S. PROVIB TECH, MUMBAI	MUMBAI	1. M/S ProvibTech,	USA
				2. M/S. BENTLY NEVADA,	USA
				3. M/S. SHINKAWA,	JAPAN
				4. M/s. MEGITT, SWITZERLAND	SWITZERLAND
106	SMPS	1. M/S. RATO, HYDERABAD	HYDERABAD		
		2. M/S. CHIRRA, BANGALORE	BANGALORE		
		3. M/S. SM CREATIVE ELECTRONICS LTD., GURGAON	GURGAON		
		4. M/S. ECIL, HYDERABAD	HYDERABAD		
107	COAXIAL CABLES			1. M/S. CABLETEL, FRANCE	FRANCE
				2. M/S. HABIA CABLES, SWEDEN	SWEDEN
				3. M/S. NEXAN, FRANCE	FRANCE
108	BRASS NICKEL PLATED WITH CHROMIUM FINISH CABLE GLANDS & PLUGS	1. M/S. COMET BRASS PRODUCTS, MUMBAI	MUMBAI		

		2. M/S. ELECTROMAC INDUSTRIES			
109	PROFIBUS ACCESSORIES	1. M/S. SIEMENS, MUMBAI	MUMBAI	1. M/S. SIEMENS, GERMANY	GERMANY
		2. M/S. PEPPERL + FUCHS , MUMBAI	MUMBAI	2. M/S. SCHNEIDER ELECTRIC, FRANCE	FRANCE
				3. M/S. TRUCH AUTOMATION, GERMANY	GERMANY
110	ETFE/PTFE, INSUL. WIRES & CABLES	1. M/S. R.J. INDSUTRIAL CORPORATION, ROORKEE	ROORKEE		
		2. M/S. FLU-TEF INDSUTRIES, AHMEDABAD	AHMEDABAD		
		3. M/S. T & F INSUALTION PVT., LTD., BULANDSHAHR	BULANDSHAHR		
		4. M/S. DELTION CABLES LTD., NEW DELHI	DELHI		
		5. M/S. MANSFIELD CABLES CO., LTD., NOIDA, UP	NOIDA, UP		
		6. M/S. SBEE CABLES (i) LTD., KANAKAPURA ROAD	ROAD		
		7. M/S. RALLISION ELECTRICALS PVT., LTD., BANGALORE	BANGALORE		
		8. M/S. TECHNO CABLES PVT., LTD., NEW DELHI	NEW DELHI		
		9. M/s.Trestar, Gaziabad	Nashik		
		10. M/s.Sanghvi Wires, Hyderabad	Hyderabad		
111	DISPLACER TYPE (TOP MOUNTED) LEVEL SWTICHES	1. M/S. LEVCON INSTRUMENTS PVT. LTD.,KOLKATA		1. M/S. KDG MOBREY, UK	UK
		2. M/S. TRANSDUCERS & CONTROL PVT., LTD., HYDERABAD	HYDERABAD		
		3. M/S. CHEMTROLS ENGG., LTD, MUMBAI	MUMBAI		
		4. M/S. PUNE TECHTROLS, PUNE			
		5. M/S. SBEM, PUNE	PUNE		

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Section-C
PART-2

C-1: SPECIFIC TECHNICAL REQUIREMENTS

APPENDIX

NUCLEAR POWER CORPORATION OF INDIA LTD

(A GOVT. OF INDIA ENTERPRISE)

SPECIFICATION NO : PC-E-501/R1

TECHNICAL SPECIFICATION
ON
MEDIUM VOLTAGE MOTORS OF CAPACITY EQUAL TO OR LESS THAN 50kW FOR 700MWe

REF USI NO: 50200

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NO: PC-E/501/R1

TITLE: TECHNICAL SPECIFICATION FOR MEDIUM VOLTAGE MOTORS OF CAPACITY EQUAL TO OR LESS THAN 50kW FOR 700MWe

REV NO & DATE	DESCRIPTION OF REVISION	REVISED BY NAME & SIGNATURE	CHECKED BY NAME & SIGNATURE	REVIEWED BY NAME & SIGNATURE	APPROVED BY NAME & SIGNATURE
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1.0 SCOPE

This specification covers the technical requirements for design, manufacture, inspection, testing, supply and guarantee of Medium voltage induction Motors of capacity equal to or less than 50kW.

2.0 STANDARDS

The motors shall conform to the latest editions of the following standards unless specified otherwise in this specification.

IS	325	:	Three-phase induction motors - Specification
IS	14578	:	Three-phase induction motors for use in nuclear power plants - Specification
IS	12615	:	Energy efficient induction motors - Three phase squirrel cage
IS	12075	:	Mechanical vibration of rotating electrical machines with shaft heights 56mm and higher- Measurement, evaluation and limits of vibration severity
IS	9283	:	Motors for submersible pump sets - Specification
IS	15881	:	Three phase cage induction motor specifically designed for IGBT converter supply - Specification

In case of conflicts, requirements stated in this specification shall govern.

3.0 OPERATING CONDITIONS

3.1 Motors shall be suitable for continuous operation under the following operating conditions:

1.	Ambient temperature at the location of motor	50^0 C
2.	Site altitude	Less than 1000mtrs
3.	Humidity	90% at 40^0 C
4.	Rated voltage and its variation	415V+/-10%
5.	Rated frequency and its variation	50Hz+/-5%
6.	Number of Phases	3
7.	Combined variation	10%
8.	Unbalance in supply voltage	3%
9.	Permissible harmonics in the supply voltage	5%
10.	Method of power supply system grounding	Effectively grounded system.

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11.	Power supply voltages for auxiliaries	(a) 240V AC, 50Hz, 1-Phase for space heater. (b) 240V AC, 50Hz, 1-Phase or 24V DC for instrumentation and Controls.
12.	Temperature rise of motor winding under normal operating conditions of voltage and frequency (By winding resistance method)	70^0C (except submersible motor pump set)
13.	Temperature rise of motor winding under extreme conditions of voltage and frequency (By winding resistance method).	80^0C (except submersible motor pump set)
14.	Seismic requirements	If specified in annexure-A, total assembly shall be qualified and documented to prove its capability to withstand specified seismic accelerations.
15.	Radiation dose for which motors located inside the reactor building required to be designed.	As specified in Annexure-A
16	External over pressure for motors inside reactor building during reactor building pressure test.	Motors and their auxiliaries shall withstand satisfactorily external pressure specified in annexure-A

4.0 DESIGN REQUIREMENTS

4.1 General

4.1.1 Motors shall be designed, manufactured, inspected and equipped with accessories in accordance with this specification, Annexure-A and the applicable standards. Materials and components not specifically stated in this specification and which are necessary for meeting the operational and or performance requirements of this specification should be included in the scope of supply.

4.1.2 Design and manufacture of the motors shall be coordinated with the requirements of the driven equipment. The motor manufacturer shall co-operate fully with the Purchaser and the manufacturer of the driven equipment by furnishing required information for proper assembly and operation of the unit as a whole and to offer a motor suitable for the driven equipment duty and application. Typically, the

details that may have to be exchanged between the driven equipment vendor and the motor vendor would include:

i) A copy of this specification including Annexure-A, Load Torque vs Speed characteristics, load GD^2, rated speed, number of starts/restarts, operating duty, load on bearings, mounting, provisions to be made by the motor vendor for ensuring proper coupling, instrumentation, location etc

ii) A fully dimensioned outline drawing of the motor, shaft, mounting details and its terminal box arrangement.

iii) Technical particulars and characteristic curves as asked in Annexure 'B' of this specification.

iv) If specified, submitting all details that are required by the agency performing seismic analysis of motor and the driven equipment as a single unit.

4.1.3 When motors are purchased with the driven equipment, driven equipment supplier shall be responsible to the Purchaser for coordinating with the motor manufacturer for supply of required motors and accessories as per this specification and for satisfactory operation of complete unit.

4.1.4 Where the quantity is more than one, similar parts shall be physically and technically interchangeable between the motors.

4.1.5 Design, manufacture, inspection, testing, qualification and performance of motors shall be in accordance with the particulars specified in Annexure-A to this specification.

4.1.6 Minimum efficiency of motors shall be as per relevant Indian Standards (IS) and efficiency class shall be as given in Annexure-A. Starting current shall be limited as per the particular efficiency class given in the relevant Indian Standards (tolerance as per IS) unless otherwise specified.

4.1.7 Motors if powered through electronic Pulse Width Modulated or any similar variable speed drives shall be suitably designed to take in to account harmonics and voltage surges generated by such drives. Suitability of the motor for operation with such drives shall be confirmed. CONTRACTOR shall coordinate between the drive vendor and the motor vendor so as to ensure total compatibility.

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4.2 **Rotor**

4.2.1 The squirrel cage rotor design shall provide a rigid cage construction with aluminum die cast rotor. Alternatively, rotor with copper bars firmly wedged in slots and solidly bonded by brazing to the copper end rings is also acceptable. Brazing and brazing procedures shall be qualified in accordance with acceptable standards. The end ring assembly shall be such that it is free to move with the expansion of the bars without distortion. The rotor cage shall be designed to operate satisfactorily under specified repetitive starting and load cycles. The rotor end lamination shall be rigidly fixed to prevent flaring.

4.2.2 Slip ring motors shall be provided with class-F insulated copper conductor winding and processed in vacuum with Class-F varnish or resin. The temperature rise limits shall correspond to class-B limits. The overhang portion of windings shall be provided with strong supporting arrangement to prevent it's flaring due to action of centrifugal forces during operation and over speeding conditions. Slip ring motors shall be provided with slip ring and brush gear. The design of slip ring and brush gear shall be proven, rugged, non-hygroscopic, anti-tracking and shall have excellent stability at high temperature.

4.3 **Stator (except submersible motor pump set)**

4.3.1 Motor shall be insulated to class 'F' insulation with temperature rise limited to class B. The insulation system shall be of proven design and shall have high dielectric strength, high mechanical strength and long life.

4.3.2 Complete assembly of stator winding and overhang shall be impregnated in resin/ varnish using Vapour Pressure Impregnation (VPI).

4.3.3 The supplier shall describe the insulation and insulation treatment and its capacity to meet the operating requirements specified.

4.3.4 Motor core and winding shall be protected against (a) tropical weather conditions (b) fungus growth and moisture (c) oil (d) abrasive and conducting dust and chemical fumes that are likely to be encountered in and around the power plant area. For this purpose manufacturer shall provide non-hygroscopic & non-digestible (to fungus/mold) insulation material and suitable gel coating.

4.3.5 Overhang portion shall be adequately braced to withstand forces due to repeated restarts and fast transfer voltage conditions. The supports for the overhang portion shall be of non-magnetic material.

4.3.6 Motors located inside the reactor building shall be provided with insulation systems, terminal supports, gaskets, seals, lubricating oil or grease etc capable of withstanding specified level of radiation dose during its service life.

4.3.7 Stator windings shall be of insulated copper conductors.

4.4 **Enclosure**

4.4.1 Motors shall be provided with enclosure providing a degree of protection not less than IP 44 unless other wise specified in Annexure-A. For submersible pump motors, the degree of protection provided by enclosures shall be minimum IP-68.

4.4.2 Motors shall be self-ventilated unless otherwise specified. All out door motors shall be provided with a suitable canopy to prevent rainwater from entering motor and terminal boxes.

4.5 **Frame, End-shields, Fans and other fabricated parts**

4.5.1 Frame, end shields etc of the motor shall be of cast steel or cast iron grade FG 200 or aluminium alloy or better. Incase of alternatives, it shall be made in the offer indicating complete chemical and physical properties of material. However, use of such material is permitted only after obtaining Purchaser's approval against a specific request of vendor for use of such alternate material.

4.6 **Terminal Boxes (except submersible motor pump set)**

4.6.1 Terminal boxes for motors greater than 15kW shall be provided with clearances between phases and phase to earth greater than or equal to 25mm. Terminal boxes for motors less than or equal to 15kW shall be provided with clearances as per applicable standards. Adequate space shall be provided for easy termination of Purchaser's cable.

4.6.2 Terminal boxes shall be suitable for top and bottom or side entry of cables and shall be provided with **EPDM/XLPE** gaskets on all bolted joints to provide a degree of protection equal to IP 55. The terminal boxes shall be suitable for terminating the purchaser's cables as specified in Annexure 'A'.

4.6.3 Supply and mounting of cable glands required for power and control cables are not in the scope of this specification and same shall be provided by the Purchaser. Adequate size of undrilled gland plates shall be provided to facilitate termination of cables.

4.6.4 Motors rated above 30kW shall be provided with auxiliary terminal box for connection to the space heater of the motor.

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4.7 Bearings and Bearing Housing

4.7.1 Motor bearings shall be constructed so as to exclude dirt and water and to prevent lubricant from reaching the windings. Grease lubricated bearings shall have easily accessible grease nipples to facilitate greasing operations. The bearing assembly shall be provided with grease relief device such that when the motor runs at rated speed any surplus grease is automatically ejected out of the motor casing to a separate container. Alternately, self-lubricated bearings may be used.

4.7.2 Vertical motors shall be provided with single or double (as required) thrust and guide bearings.

4.7.3 Ball and roller bearings shall have a minimum calculated L10 basic rating life of 40,000 running hours and Sleeve bearings shall have a minimum life of 100,000 hours of operation, after considering (a) all the forces that normally occur and (b) seismic forces. Motor manufacturer shall obtain from the driven equipment manufacturer all necessary details required for selection of bearing and in consultation with the bearing vendor, select suitable bearings. Complete details regarding selection and technical particulars of bearings provided shall be submitted to the Purchaser after placement of order.

4.7.4 Operating temperature of bearings under all conditions shall be within the limits prescribed by the bearing manufacturer.

4.7.5 Bearings shall be designed to permit motor running in either forward or reverse directions as required by the driven equipment.

4.7.6 Lubricant shall be selected for prolonged storage and use of the motor in a tropical climate and shall contain corrosion and oxidation inhibitors and anti foaming agents. Grease shall have suitable bleeding characteristics to minimize setting. Data regarding suggested re greasing intervals shall be furnished in the offer. In case of reactor building motors, which are required to operate following Loss of Coolant Accident (LOCA)/ Main Steam Line Break (MSLB), bearing lubricant shall be capable of withstanding pressure and temperature conditions prevailing at the location during and subsequent to LOCA/MSLB.

4.8 Balancing and Vibration

4.8.1 Vibrations in all the three directions for horizontal motors shall be within the limits specified in IS-12075. For vertical motors the measured values shall not exceed the limits at the bottom bearings. Type test certificate/report for amplitudes and velocity of vibration in all directions shall be submitted for Purchaser's review/acceptance.

4.8.2 Balancing of rotor with all components mounted shall be carried out at rated RPM or as permitted by the standards. Balancing shall be to grade Gr 2.5 according to ISO 1940. Dynamic balancing of rotor for submersible motor pump set shall be as per IS 9283. Report shall form part of Routine test reports.

4.9 **Grounding**

4.9.1 Provision shall be made on the motors for connecting Purchaser's grounding conductors.

4.10 **Space Heaters (except submersible motor pump set)**

4.10.1 Motors of capacity greater than 30kW (except submersible motor pump set) shall be provided with space heaters of adequate capacity to maintain motor internal temperature above the dew point to prevent moisture condensation when the motor is not in service. The heaters shall be mounted inside the motor in accessible place so that their removal and replacement is a simple operation. Space heaters shall be rated for 240 volts, single phase, 50 Hz operation and shall be located in lower part of motor.

4.11 **Couplings**

4.11.1 Driven equipment manufacturer shall work out details of coupling arrangement. Motor manufacturer shall provide necessary information to the driven equipment supplier and meet the requirements of the driven equipment manufacturer.

4.12 **Direction of Rotation**

4.12.1 Direction of rotation shall be as required by the driven equipment and the same shall be indicated in drawings, documents and motor frame.

4.12.2 If specified in Annexure-A, a mechanical device to prevent reverse rotation shall be provided. The rating of mechanical reverse rotation stop shall be such that it can prevent reverse rotation when the torque in the reverse direction is not greater than 100% of rated torque of the motor in the forward direction.

4.13 **Mounting and Dowelling**

Mounting arrangement shall be matched with the requirements of the driven equipment.

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4.14 **Lifting facility**

Motors shall be provided with adequately designed eyebolts, lugs or other devices to facilitate safe lifting operations.

4.15 **Drain Plugs**

Motors should have drain plugs to permit removal of water accumulated inside the motor.

4.16 **Base Frames**

When a motor is supplied with driven equipment having common base frame, the supplier of the driven equipment shall determine that such base frame is adequately braced to keep vibration and misalignment within permissible limits. Driven equipment supplier shall be responsible for supply of all required mounting arrangements considering the motor and driven equipment assembly.

4.17 **Name plate and Diagram of Connections**

Each motor shall have a nameplate showing all the particulars specified in relevant clause of IS-325. In addition, the nameplate shall also indicate (a) the type of bearings used for motor, (b) details of recommended lubricant and (c) Re-lubrication interval & quantity

5.0 **PERFORMANCE REQUIREMENTS**

5.1 **Starting Duty**

5.1.1 The motors shall be capable of two successive restarts coupled to its driven equipment with coasting to rest between starts under both cold and hot conditions and a third restart shall be feasible after 20 minutes. The motor shall further be capable of three equally time spaced starts per hour under normal service conditions. In case of motors for valve actuators, cranes, lifts, hoists etc which are subjected to repeated starting, stopping, reversing etc, the starting duty shall be commensurate with the requirements of the driven equipment.

5.1.2 Motors shall be designed for direct on line, full voltage starting and shall withstand all stresses and give satisfactory performance when started with their driven equipment connected under all operating conditions specified for the driven equipment. The complete rotating system of motor and driven equipment and end windings of stator, and rotor shall be adequately designed to cater to the different starting duty conditions etc. The total number of starts during the design

life of motor shall be commensurate with the requirements of driven equipment and taking into account design life of motor.

5.1.3 Motor shall be capable to starting and accelerating the driven equipment satisfactorily at a minimum voltage of 80% of the nominal voltage at the motor terminals.

5.2 **Locked Rotor current for squirrel cage rotor**

Locked rotor current shall be as per the values given in Indian Standard for the required efficiency class (Tolerance shall be as per standard) unless otherwise specified.

5.3 **Fast Bus Transfer**

Motors and driven equipment shall be capable of withstanding the voltage torque stresses and forces developed due to the vector difference between the motor residual voltage and the incoming supply voltage during fast changeover of the supply. Motor winding shall be adequately braced to withstand mechanical forces developed during such conditions.

5.4 **Pull out:**

Motor shall not pull out of step when the supply voltage drops to 70% of the rated motor voltage for a short duration of 25 cycles during full load operation of motor. To meet this requirement, the pull out torque of the motor at rated voltage shall be at least 200% of full load torque.

5.5 **Over speed**

The motors shall be capable of withstanding without mechanical damage, at least 120% of rated speed or as imposed by the driven equipment, whichever is higher.

5.6 **Other requirements**

5.6.1 Motors shall be capable of satisfactory operation at full load without injurious heating when the motor terminal voltage is at 80% of rated voltage for ten minutes. Motors shall be capable of withstanding 160% rated torque for 15 and 10 seconds for normal motors and submersible motor pump set respectively.

5.6.2 In all cases involving centrifugal pumps, compressors, fans etc. the acceleration time of motor at 80% terminal voltage shall not be greater than the locked rotor withstand time under hot condition at 100% voltage. The safe stall time of the motor shall be such that taking in to account the accelerating time of the motor

with the driven equipment and specified number of hot and cold starts, adequate margin exists and the motor remains safe. The permissible stator and rotor temperatures for the purpose of calculating safe stall times shall be limited to 185^0 C for stator with class-F insulation and 300^0C for aluminum die cast rotor or 400^0C for rotors with copper bars.

5.6.3 If specified in Annexure-A, driven equipment vendor by analysis of complete assembly of motor, coupling, driven equipment and mounting arrangements shall qualify that motor and the driven equipment assembly would continue to perform intended function during and after subjected to specified level of earthquake with out any deterioration in the performance.

5.6.4 Motors provided with power supplies from variable frequency drives shall be suitably designed and tested to take care of effects of such power supplies on motor performance.

6.0 SPARES

The supplier shall recommend spares that are required for 5 years operation and required to be stocked for maintenance purpose. However, as a minimum, supplier shall furnish prices for the following in his tender.

i) One set of complete bearing assembly for drive and non-drive end bearings.
ii) One complete motor.
iii) One set of space heaters; wherever motors are provided with space heaters.
iv) Seals and other materials that require periodic replacement (if provided).

All spares to be supplied should be physically and technically interchangeable with similar components already installed/in use.

7.0 INSPECTION AND TESTS

7.1 All routine tests mentioned in IS-325/9283 shall be conducted **on all motors** by the manufacturer at his work in the presence of main contractor and/or purchaser's representative. Inspection call for routine tests shall be given two weeks in advance from date of commencement of routine tests as witness point. After lapse of the notice time, manufacturer can proceed with the routine tests. Routine test certificates shall be furnished to the Purchaser's representative (QA) for review & acceptance. Cost for the same shall be included in the equipment prices.

7.2 Test certificates for type tests performed on identical motors as per IS 325/9283 shall be submitted along with the documents and data sheets for review and approval of the Purchaser. In case type test reports are not acceptable to the

Purchaser, type tests shall be performed at no extra cost to the Purchaser and with out affecting the delivery period. Type test reports shall not be earlier than 5 years from the date of purchase order. Test certificates shall be submitted for review and approval of the Purchaser. Any special tests and qualification tests if specified in Annexure-A shall be performed in accordance with an approved test procedure and test reports submitted after due qualification. Special & qualification tests shall be conducted in presence of purchaser's representative Charges for special tests shall be indicated separately and shall be payable if tests are conducted and results are acceptable.

7.3 The Purchaser or his authorised representative shall at all reasonable times have access to those parts of the supplier' s or sub-supplier's works concerned with the manufacture of the motor for the purpose of witnessing tests and ascertaining compliance with the requirements of this specification. The Purchaser shall also have the right to conduct at his expense any additional tests or inspection he deems necessary.

7.4 The contractor shall supply to Purchaser's representative a complete set of detailed fabrication drawings which will be used in the inspection during manufacture, which will be retained at the factory and returned after completion of the contract.

7.5 All repairs and rework shall be informed to the Purchaser and his approval in writing taken before proceeding further. All such repair work shall be documented and photographic records shall be maintained. These documents shall be included in end documents.

8.0 PAINTING AND PACKING:

8.1 The motor external parts shall be finished and painted to produce a neat and durable surface, which would prevent rusting, and corrosion. The equipment shall be thoroughly degreased, all rust, sharp edges and scale removed. The painting system shall be having a primer based on inorganic Ethyl zinc silicate (for RB motors)/ zinc phosphate and compatible with epoxy paint system and top coats of epoxy paint system to shade 631 of IS-5 or RAL-7032.

8.2 All materials/ spares that have limited shelf life shall be marked with expiry date in bold to indicate their storage conditions.

8.3 The motor shall be packed for dispatch to project site in strong wooden crates. The following information shall be clearly given on each box.

a) Purchaser

b) Purchaser order number

c) Equipment code number, if any.

d) List of contents of each package

e) Storage instructions

8.4 The packing should incorporate measures to prevent damage to motor winding, bearing and shaft due to jerks and shocks during transit. The packing should afford reasonable protection against ingress of rainwater.

9.0 DRAWINGS AND DOCUMENTS

9.1 Within 4 weeks of placement of purchase order, the supplier shall furnish for Purchaser's approval following drawings:

a) Drawings showing overall dimensions and all other essential dimensions along with cross-sectional views and data sheets as given in Annexure-B.

b) Detailed drawing for terminal boxes, clearance, conductor termination, cable gland and degree of protection should also be marked on this drawing.

c) Write up on the insulation system provided for the motor winding as part of motor datasheet.

d) All details submitted to the driven equipment supplier for the purpose of seismic qualification of the driven equipment and the motor assembly, application check for the motor to confirm suitability of the motor to the requirements of driven equipment.

9.2 Supplier shall take up manufacture after the Purchaser has approved the drawings.

9.3 Three prints of all drawings and documents shall be submitted for approval. After execution of the order, three sets of hard copies of drawings and documents and two sets of CDs with all scanned copies of documents, drawings, data sheets and characteristic curves and routine and type test reports including reports of special tests if performed shall be supplied.

9.4 Following characteristic curves shall be supplied:

9.4.1 Torque v/s speed curves for the motor superimposed with load torque vs speed characteristics.

9.4.2 Starting current v/s time

9.4.3 Power factor, efficiency, load current v/s Load

9.4.4 Thermal withstand characteristics for motor under cold and hot conditions.

10.0 INSTRUCTION MANUALS

10.1 Supplier shall furnish three hard copies of instruction manuals and two CDs with completely scanned copies of documents covering storage, installation, detailed assembly, disassembly procedures, operation and maintenance of the motors. Installation instructions shall include procedure for checking alignment of motor shaft, coupling and base. Instruction shall also cover lubricating details including recommended inspection and replacement schedules, quantity of lubricant required and specifications for the lubricant and its equivalent. Instruction manual shall include one set of all approved drawings, a complete part list, descriptive literature for all components such as space heaters etc and complete details of motor in Annexure - B as per requirement.

10.2 In addition, three copies of the above instruction manual shall be supplied with each motor.

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Motor Tag Nos:
Quantity:
Project Title:

	Process Group	Electrical Design Group
Prepared by		
Reviewed by		
Approved by		

.

Sl.No.	Particulars	
1.0	**SPECIAL SITE CONDITIONS**	
1.1	Type of environment (corrosive/non-corrosive)	
1.2	Location (indoors/outdoors)	
1.3	Hazardous condition.	
1.4	Whether the Motor is supplied from variable frequency variable voltage drives or similar such electronic drives (Yes, the motor shall be designed adequately to take in to account voltage output from such drives **/** No, the motor is provided with normal power supply)	
2.0	**GENERAL**	
2.1	Application/Driven equipment	
2.2	Type of motor (SCR/SR)	
2.3	Type of submersible motor pump set, (Wet Type/Resin Filled/Sealed)	
2.4	Efficiency class of motor (IE1/IE2/IE3/any other class)	
2.5	Nature of application of the motor (Motor is safety related/Motor is not safety related but critical/General)	
2.6	Lower critical speed of motor	>130% of rated speed
2.7	Length of cable for submersible motor pump set, (m)	
2.8	Permissible voltage drop of 15m cable length for submersible motor pump set	≤1% of rated voltage
3.0	**RATING**	Driven equipment vendor to select the rating considering all operating conditions and provide a minimum margin of 10%
4.0	**DUTY**	
4.1	Type of duty (S1 to S8)	
5.0	**STARTING**	
5.1	Method of starting	
5.2	Number of successive starts on full load followed by next start after 20 minutes. (A) In cold condition (B) In hot condition.	 Minimum 2 Minimum 2
5.3	No. of equally spread starts per hour.	Minimum 3

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6.0	**INSULATION**	
6.1	Class of insulation for stator/Rotor winding	Minimum Class-F
7.0	**ENCLOSURE**	
7.1	Type of enclosure.	
7.2	Degree of protection.	
7.3	Type of cooling	
8.0	**TERMINAL BOXES**	
8.1	No. of cable entries.	
8.2	Power cable size and type.	
8.3	Separate terminal box required for: Stator phase terminals (Yes/No) Rotor phase terminals (Yes/No) Space heater terminals (Yes/No)	
8.4	Size of cable for space heater external connection	2.5 sq.mm Cu. conductor, 2 core HRPVC/XLPE cable or as required.
8.5	Location of terminal boxes when viewed from non driving end of the motor	Left / Right / top
9.0	**BEARINGS**	
9.1	Type of bearings	
9.2	Type of lubrication	
9.3	Expected re-lubrication interval	
10.0	**INSPECTION AND TESTING**	
10.1	Whether any special tests other than those indicated in the specifications and Indian Standards are required to be performed? (Yes/No) If so, indicate details.	
10.2	Whether seismic qualification of motor and its driven equipment required to be performed? If yes, identify operability / structural integrity requirements under SSE and OBE.	
11	**Special Requirements for Reactor building motors**	
11.1.	Whether motor is required to be qualified for operation during and following LOCA/MSLB? (Yes/No*)	
11.2	If LOCA/MSLB qualification is required, are the corresponding pressure and temperature transient curves enclosed? (Yes/No)	
11.3	Cumulative radiation dose under normal and accident conditions.	

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11.4	Motor tag number for which LOCA/MSLB qualification is required.	
11.5	Whether motor insulating materials, gaskets, lubricants etc required to withstand radiation and operate satisfactorily under normal conditions? (Yes/No)	
11.6	Cumulative radiation dose under normal conditions	
11.7	Whether motor is required to be qualified to withstand radiation under normal conditions? (Yes/No)	
11.8	Tag numbers of motors for which radiation qualification for normal conditions is required but LOCA and MSLB qualification is not required	
11.9	Expected external over pressure likely to be experienced by motors and their accessories during reactor building pressure test.	

* Detailed procedure shall be worked out by the Contractor and subjected to review and approval of Purchaser.

NUCLEAR POWER CORPORATION OF INDIA LIMITED	
ANNEXURE-B TO PC-E-501 FORMAT FOR SUBMISSION OF TECHNICAL PARTICULARS FOR MEDIUM VOLTAGE INDUCTION MOTORS EQUAL OR LESS THAN 50kW FOR 700MWe (To be filled in by Motor Manufacturer and submitted through driven equipment Manufacturer / Package Contractor)	**Project: 700MWe** **Page : 1 of 8**

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1.	Name and address of Motor Manufacturer		:	
2.	Name and address of driven equipment manufacturer		:	
3.	Name and address of Package contractor		:	
4.	References		:	
	i)	NPCIL's Purchaser Order No.	:	
	ii)	Package Contractor's Purchase Order No.	:	
	iii)	Driven Equipment Supplier's Purchase Order No	:	
	iv)	Work Order Number of Motor Manufacturer	:	
5.	NPCIL Document No.		:	
6.	Rev. No. & Date		:	
7.	Motor Tag Nos.		:	
8.	Quantity		:	
9.	Project Title		:	
10.	Contents		:	
	i)	Motor data sheets	:	Sheet 1 to 8
	ii)	Motor & load Torque v/s Speed Curves	:	Sheet 9
	iii)	Performance Curves	:	Sheet 10
	iv)	Current v/s starting time	:	Sheet 11
	v)	Thermal withstand characteristics	:	Sheet 12
	vi)	Name Plate Drawing	:	Sheet 13
	vii)	Power Terminal Box Drawing	:	Sheet 14
	viii)	Space Heater Terminal Box Drawing	:	Sheet 15

	Motor Manufacturer	Driven Equipment Supplier	Package Contractor
Prepared by			
Reviewed by			
Approved by			

Motor manufacturer's name and address	**Date of issue, Rev No**

NUCLEAR POWER CORPORATION OF INDIA LIMITED	
ANNEXURE-B TO PC-E-501 FORMAT FOR SUBMISSION OF TECHNICAL PARTICULARS FOR MEDIUM VOLTAGE INDUCTION MOTORS EQUAL OR LESS THAN 50kW FOR 700MWe (To be filled in by Motor Manufacturer and submitted through driven equipment Manufacturer / Package Contractor)	**Project: 700MWe** **Page : 2 of 8**

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Sl.No.	Particulars	
1.0	**Guaranteed operating conditions for the motor**	
1.1	Ambient temperature, ^{0}C	
1.2	Altitude, M	
1.3	Humidity at 40^{0}C, (%)	
1.4	Type of environment (corrosive/non-corrosive)	
1.5	Location (indoors/outdoors)	
1.6	Hazardous condition (Yes/No)	
1.7	Rated voltage & its variations, (V)	
1.8	Rated frequency & its variations, (Hz)	
1.9	Permissible un-balance in supply voltage, (%)	
1.10	Permissible harmonic content in supply voltage, (%)	
1.11	Combined voltage & frequency variations, (%)	
1.12	Number of phases	
1.13	Method of system grounding.	
1.14	Seismic capability: if specified in the annexure-A, whether qualification of motor and the driven equipment assembly along with accessories and auxiliaries included in the scope of the tender? Identify the methodology for seismic qualification.	
1.15	Radiation withstand capability of the motor	
1.16	Auxiliary power supply requirements for space heaters	
1.17	Whether the motors are adequately designed to operate satisfactorily when supplied with power supply from electronic drives intended to be used for the driven equipment?	
2.0	**GENERAL**	
2.1	Application/Driven equipment	
2.2	Method and type of coupling to driven equipment.	
2.3	Type of motor (SCR/SR)	
2.4	Frame size	
2.5	Mounting	
2.6	Single shaft / double shaft extension.	
2.7	Direction of rotation (viewed from drive end)	
2.8	Rotation – uni /bi-directional	
2.9	Reverse rotation stop provided?	
2.10	Applicable standards/codes.	
2.11	Stator winding connection	
2.12	Winding resistance per phase*	

Motor manufacturer's name and address	**Date of issue, Rev No**

NUCLEAR POWER CORPORATION OF INDIA LIMITED	
ANNEXURE-B TO PC-E-501 FORMAT FOR SUBMISSION OF TECHNICAL PARTICULARS FOR MEDIUM VOLTAGE INDUCTION MOTORS EQUAL OR LESS THAN 50kW FOR 700MWe (To be filled in by Motor Manufacturer and submitted through driven equipment Manufacturer / Package Contractor)	**Project: 700MWe** **Page : 3 of 8**

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3.0	**RATING**		
3.1	Rated output (KW)		
3.2	Rated speed (RPM)/Synchronous speed (RPM)		
3.3	KW actually required by the drive equipment under specified operating conditions.		
4.0	**DUTY**		
4.1	Type of duty		
5.0	**STARTING**		
5.1	Method of starting		
5.2	Starting current (% of full load current)		
5.2.1	At rated voltage		
	a)	Including I.S. tolerance	
	b)	Excluding I.S. tolerance (Committed value)	
5.2.2	At 80% voltage		
	a)	Including I.S. tolerance*	
	b)	Excluding I.S. tolerance*(Committed value)	
5.3	Minimum voltage required for starting (% of rated voltage)		
5.4	Starting time with DOL starting with driven equipment coupled		
	a)	At rated voltage, (sec)	
	b)	At 80% voltage *, (sec)	
5.5	Max. No. of successive starts on full load		
5.5.1	In cold condition		
5.5.2	In hot condition		
5.6	No. of equally spread starts per hour		
6.0	**INSULATION**		
6.1	Class of insulation for stator		
6.2	Permissible temperature rise (by resistance method)		
	a)	Under normal conditions, (^{0}C)	
	b)	Under extreme voltage conditions (90/110% of rated voltage whichever is severe), (^{0}C)	
6.3	Tropical Treatment of motor		
6.3.1	Material of insulation		
6.3.2	Treatment of insulation, stator and rotor core for anti-fungal growth		
7.0	**COSTRUCTION & MATERIALS**		
7.1	Degree of protection provided by the enclosure		
7.2	Enclosure type (Fabricated type/ casting)		

Motor manufacturer's name and address	**Date of issue, Rev No**

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7.3	Enclosure material grade for		
	a)	Frame	
	b)	End shields	
	c)	Power terminal box	
	d)	Bearing housing	
	e)	Gaskets	
7.4	Material for stator conductors		
7.5	Material for rotor bars, (Cu, Al)		
7.6	Heat loss to environment for the purpose of ventilation design *		
7.7	Type of cooling		
7.8	Painting		
7.8.1	Primer (Epoxy system having polyamide cured non-inhibitive epoxy primer?), (Yes/ No)		
7.8.2	Finish Coats (Polyamide cured epoxy?), (Yes/No)		
8.0	**TERMINAL BOXES**		
8.1	Type of main terminal Box		
8.2	Degree of protection for T. Box enclosure		
8.3	No. of cable entries*		
8.4	Max. cable size suitable for the terminal box/Actual cable size, (sqmm)*		
8.5	Direction of cable entry		
8.6	Size of cable gland plate suitable for		
	a)	Motor cable*	
	b)	Space heater cable*	
8.7	Cable type & length for submersible motor pump set		
9	**BEARINGS**		
9.1	Type of bearing		
9.2	D.E bearing number and make.		
9.3	N.D end bearing number and make		
9.4	Standard L10 life of bearing.		
9.5	Type and grade of lubricant*		
9.6	Bearing end play (mm)* Axial Radial		
9.7	Thrust bearing losses*		
9.8	Regressing interval		
9.9	Maximum permissible bearing temperature, (^{0}C)		

Motor manufacturer's name and address	**Date of issue, Rev No**

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	DE NDE		
9.10	Whether bearings are designed considering all loads expected during all operating conditions including seismic conditions (if specified) of the driven equipment?		
9.11	Whether bearings are designed for operation during and after LOCA, (only if the requirement is specified)		
10	**ACCESSORIES**		
10.1	Space – heaters		
	a)	Voltage	
	b)	Wattage/ space heater*	
	c)	Nos. proposed to be used*	
	d)	Location*	
	e)	Expected temperature of in side air above the out side ambient air temperature*	
11	**WEIGHT AND MOMENT OF INERTIA**		
11.1	Weight of stator (Kg.)*		
11.2	Weight of rotor (Kg.)*		
11.3	Total weight of motor (Kg.)*		
11.4	Shipping weight of motor (Kg.)*		
11.5	Shipping dimensions LXBXH*		
11.6	Rotor GD^2 (Kgm^2)*		
11.7	GD^2 of driven equipment referred to motor speed (kgm^2)*		
12	**PERFORMANCE**		
12.1	Full load current (amps)		
12.2	No load current. (amps)		
12.3	Full load speed (rpm)		
12.4	No load speed (rpm)		
12.5	Efficiency At full load (%) At 75% load (%)* At 50% load (%)*		
12.6	Power factor At full load At 75% load* At 50% load* At starting*		
12.7	Noise pressure level of motor at 1.0 m at no load, db (A)		

Motor manufacturer's name and address	**Date of issue, Rev No**

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12.8	Velocity of vibration at		
	a)	No load (microns), mm/s	
	b)	With load (microns), mm/s	
12.9	Critical speed (rpm)		
	a)	Lower	
12.10	Safe stall time at 80% & 100% voltages, (sec)		
	i)	When motor is at rated operating temperature	
	ii)	When motor is at ambient temp	
	iii)	Limiting stator and rotor temp. considered to determine stall time, (^{0}C)	
12.11	Maximum number of starts permissible per year		
12.12	a)	Stator thermal time constant*	
	b)	Stator cooling time constant*	
12.13	Overload capacity:		
12.14	Torque		
12.14.1	Torque at full load, (% & time)		
12.14.2	Starting torque (% of full load torque) At rated voltage At 80% voltage*		
12.14.3	Pull-out torque (% of full load torque) at rated voltage		
12.14.4	Pull-up torque (% of full load torque) at rated voltage		
13.0	**CONNECTIONS**		
13.1	Stator		
13.2	Number of connections brought out		
14.0	**INSPECTION**		
14.1	Performance of routine tests in the presence of Purchaser / Package contractor as specified in Annexure-A agreed?, (Yes/No)		
14.2	Performance of all type tests as specified agreed if the Purchaser does not find type test reports acceptable?, (Yes/No)		
14.3	Whether full compliance to PC-E-501 agreed?, (Yes/No)		
15.0	**DRAWINGS, CATALOGUES, DATA SHEETS**		
15.1	Descriptive pamphlets for the offered motor enclosed?, (Yes/No)		
15.2	Torque vs. speed characteristics curve at rated voltage and frequency*		
	a)	For motor	

Motor manufacturer's name and address	**Date of issue, Rev No**

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	b)	For driven equipment	
15.3	Current vs. speed characteristic curve at rated voltage and frequency during acceleration*		
15.4	Thermal withstand characteristic curve and data in digital form for		
	a)	Hot condition*	
	b)	Cold condition*	
15.5	Current vs. time characteristic curve during acceleration*		
15.7	Efficiency, Power factor and current vs. load characteristics*		
15.8	Dimensional drawing showing cross sectional view and identification of components and their material specification, shaft, fan etc*.		
15.9	Dimensional drawing of the terminal boxes showing dimensions, permissible cable size, degree of protection, materials of fabrication, gasket material etc and the method of terminating the purchaser's incoming cables*.		
16.0	**Additional Technical Particulars for Motors in Reactor Building**		
16.1	Applicable standards		
16.2	Is the motor designed to operate under normal and Loss of coolant accident/ Main Steam Line Break conditions, (Normal condition/Normal and Accidental condition.)		
16.3	Capability of the motor to withstand specified radiation levels (Test certificate to be submitted)		
16.4	List of insulating materials used and their radiation withstand capability:		
16.4.1	Stator conductor		
16.4.2	Slot liner		
16.4.3	Slot wedge		
16.4.4	End connections		
16.4.5	Over hang portion		
16.4.6	Varnish for impregnation		
16.4.7	Motor terminal		
16.4.8	Gaskets		
16.4.9	Lubricants		
16.5	Capability of the motor to continuously operate under the specified accident conditions (LOCA/MSLB) viz. temperature, pressure and relative humidity (Test certificate to		

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	be submitted or type test shall be performed as per approved procedure).	
16.6	Capability of the motor to withstand specified seismic withstand requirements.	

Note: a) All data sheets and characteristic curves should be strictly in the above format in A4 size sheets with continuous page numbers, properly bound and provided with a cover sheet indicating names and signatures of persons responsible for preparation, checking, approving of documents at motor manufacturer, driven equipment vendor, EPC contractor etc before submission to the Purchaser. Document shall have Purchaser's purchase order reference, EPC contractor's purchase order reference and driven equipment vendor's purchase order reference, Purchaser's project identification, Motor tag numbers, revision number, date of revision etc on the cover sheet.

b) All drawings shall be in A3 size sheets and shall indicate Purchaser's project identification, motor tag numbers, purchase order numbers etc.

c) Items marked * can be submitted after placement of order and after completion of detailed engineering.

d) The vendor shall attach Sheet nos 9 to 15 referred in Cl no 10. Alternatively Sheet nos 13 to 15 can be submitted as separate documents.

Motor manufacturer's name and address	**Date of issue, Rev No**

NUCLEAR POWER CORPORATION OF INDIA LTD

(A GOVT. OF INDIA ENTERPRISE)

SPECIFICATION NO : PC-E-502/R1

TECHINAL SPECIFICATION
ON
MEDIUM VOLTAGE MOTORS OF CAPACITY GREATER THAN 50 kW
FOR 700MWe

REF USI NO : 50200

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(For Revisions See Revision Control Sheet)

FILE NAME : PC-E-502-R1

REVISION CONTROL SHEET

DOCUMENT TYPE: ENGINEERING SPECIFICATION

NO: PC-E-502-R1

TITLE: TECHNICAL SPECIFICATION FOR MEDIUM VOLTAGE MOTORS OF CAPACITY GREATER THAN 50 kW FOR 700MWe

REV NO & DATE	DESCRIPTION OF REVISION	REVISED BY NAME & SIGNATURE	CHECKED BY NAME & SIGNATURE	REVIEWED BY NAME & SIGNATURE	APPROVED BY NAME & SIGNATURE
1	GENERAL REVISION BASED ON ACCEPTED DEVIATIONS/ FEEDBACK	ROBIN RANA Robin 09/12/2016	R.M. Chovatia 09/12/2016	09 Dec 2016 (B.G. BALIGA) 9/12/16 (S.P. GANTHAR)	9/12/2016 (SRIRAMARAO)

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1.0 SCOPE

This specification covers the technical requirements for design, manufacture, inspection, testing, supply and guarantee of Medium voltage induction Motors of capacity greater than 50kW.

2.0 STANDARDS

The motors shall conform to the latest editions of the following standards unless specified otherwise in this specification.

IS	325	:	Three-phase induction motors - Specification
IS	12075	:	Mechanical vibration of rotating electrical machines with shaft heights 56mm and higher- Measurement, evaluation and limits of vibration severity
IS	14578	:	Three-phase induction motors for use in nuclear power plants - Specification
IS	12615	:	Energy efficient induction motors - Three phase squirrel cage
IS	9283	:	Motors for submersible pump sets - Specification
IS	15881	:	Three phase cage induction motor specifically designed for IGBT converter supply - Specification
IEC	60034	:	Rotating Electrical Machines

In case of conflicts, requirements stated in this specification shall govern.

3.0 OPERATING CONDITIONS

3.1 Motors shall be suitable for continuous operation under the following operating conditions:

1.	Ambient temperature at the location of motor	50^0 C
2.	Site altitude	Less than 1000mtrs
3.	Humidity	90% at 40^0 C
4.	Rated voltage and its variation	415V+/-10%
5.	Rated frequency and its variation	50Hz+/-5%
6.	Number of Phases	3
7.	Combined variation	10%
8.	Unbalance in supply voltage	3%
9.	Permissible harmonics in the supply voltage	5%
10.	Method of power supply system grounding	Effectively grounded system.

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11.	Power supply voltages for auxiliaries	(a) 240V AC, 50Hz, 1-Phase for space heater. (b) 240V AC, 50Hz, 1-Phase or 24V DC for instrumentation and Controls.
12.	Temperature rise of motor winding under normal operating conditions of voltage and frequency (Measured by winding resistance)	70^0 C (except submersible & canned motor pump set)
13.	Temperature rise of motor winding under extreme conditions of voltage and frequency (Measured by winding resistance)	80^0 C (except submersible & canned motor pump set)
14.	Seismic requirements	If specified in Annexure-A, total assembly consisting of motor and driven equipment shall be qualified and documented to prove its capability to withstand specified seismic accelerations.
15.	Radiation dose for which motors located inside the reactor building required to be designed.	As specified in Annexure-A
16	External over pressure for motors inside reactor building during reactor building pressure test.	Motors and their auxiliaries shall withstand satisfactorily external pressure specified in Annexure-A

4.0 DESIGN REQUIREMENTS

4.1 General

4.1.1 Motors shall be designed, manufactured, inspected, tested and equipped with accessories in accordance with this specification, Annexure-A, Annexure-C, Annexure-D, Annexure-E and the applicable standards. Materials and components not specifically stated in this specification and which are necessary for meeting the operational and or performance requirements of this specification should be included in the scope of supply.

4.1.2 Design and manufacture of the motors shall be coordinated with the requirements of the driven equipment. The motor manufacturer shall co-operate fully with the Purchaser and the manufacturer of the driven equipment by furnishing required information for proper assembly and operation of the unit as a whole and to offer

a motor suitable for the driven equipment duty and application. Typically, the details that may have to be exchanged between the driven equipment vendor and the motor vendor would include:

i) A copy of this specification including annexure-A, Load Torque vs Speed characteristics, load GD^2, rated speed, number of starts/restarts, operating duty, load on bearings, mounting, provisions to be made by the motor vendor for ensuring proper coupling, instrumentation, location etc.

ii) A fully dimensioned outline drawing of the motor, shaft, mounting details and motor terminal box arrangement.

iii) Technical particulars and characteristic curves as asked in Annexure 'B' of this specification.

iv) If specified, submitting all details that are required by agency performing seismic analysis of motor and the driven equipment as a single unit.

4.1.3 When motors are purchased with the driven equipment, driven equipment supplier shall be responsible to the Purchaser for coordinating with the motor manufacturer for supply of required motors and accessories as per this specification and for satisfactory operation of complete unit.

4.1.4 Where the quantity is more then one, similar parts shall be physically and technically interchangeable between the motors.

4.1.5 All motors (other than canned & submersible pump motor) up to and including 132kW rating shall be of efficiency class IE3 of IS-12615 (2011) and efficiency class of motors beyond 132kW shall be as given in Annexure-A.

4.1.6 Motors if powered through electronic Pulse Width Modulated or any similar variable speed drives shall be suitably designed to take in to account harmonics and voltage surges generated by such drives. Suitability of the motor for operation with such drives shall be confirmed. CONTRACTOR shall coordinate between the drive vendor and the motor vendor so as to ensure total compatibility.

4.2 **Rotor**

4.2.1 The squirrel cage rotor design shall provide a rigid cage construction with aluminum die cast rotor. Alternatively, rotor with copper bars firmly wedged in slots and solidly bonded by brazing to the copper end rings is also acceptable. Brazing and brazing procedures shall be qualified in accordance with acceptable standards. The end ring assembly shall be such that it is free to move with the expansion of the bars without distortion. The rotor cage shall be designed to

operate satisfactorily under specified repetitive starting and load cycles. The rotor end lamination shall be rigidly fixed to prevent flaring.

4.2.2 Rotor shaft shall be of forged material. The shaft shall be ultrasonically tested as per Purchaser's specification No-PP-P-2012 and after final machining, dye penetrant tested as per PP-P-2396. Acceptance norms for defects in shafts shall be as per the PP-P-2012 and PP-P-2396 specifications.

4.2.3 Internal and external fans shall be metallic.

4.3 **Stator (except submersible & canned motor pump set)**

4.3.1 Motor shall be insulated to minimum class 'F' insulation with temperature rise limited to class B. The insulation system shall be of proven design and shall have high dielectric strength, high mechanical strength and long life.

4.3.2 Insulation system of the motor shall be vacuum impregnated. The whole assembly of stator winding and overhang shall be vacuum impregnated in resin/ varnish and heat cured.

4.3.3 The supplier shall describe insulation and insulation treatment and its capacity to meet the operating requirements specified.

4.3.4 Motor core and winding shall be protection against (a) tropical weather conditions (b) fungus growth and moisture (c) oil (d) abrasive and conducting dust and chemical fumes that are likely to be encountered in and around the power plant area. For this purpose manufacturer shall provide non-hygroscopic & non-digestible (to fungus/mold) insulation material and suitable gel coating .

4.3.5 Insulation at joints in the motor winding such as at coil connection etc shall be to the same level as that of complete motor. Additionally, joints should have minimum resistance and mechanically strong. Joints shall be braced to withstand various stresses likely to encounter during their service. Joints in stator windings shall be brazed in accordance with a qualified brazing procedure and a qualified brazer shall perform brazing. The brazing procedure and brazer qualification shall be performed in accordance with acceptable standards for brazing.

4.3.6 Overhang portion shall be adequately braced to withstand forces due to repeated restarts and fast transfer voltage conditions. The supports for the overhang portion shall be of non-magnetic material.

4.3.7 Motors located inside the reactor building shall be provided with insulation systems, wires, leads, terminal supports, gaskets, seals, lubricating oil or grease etc capable of withstanding specified level of radiation dose during its service life.

4.3.8 Stator windings shall be of insulated copper conductors.

4.4 **Resistance Temperature Detectors (RTD)**

4.4.1 Motors shall be provided with minimum of 2 RTDs per phase suitably distributed in the winding and terminated in a separate terminal box.

4.4.2 RTDs shall be 3-wire, duplex type or 5-wire simplex type.

4.4.3 One 3-wire, duplex RTD shall be embedded in each bearing respectively.

4.4.4 RTDs shall be platinum, having a D.C. resistance of 100 ohms at 0 Deg.C.

4.4.5 The RTDs shall comply with the latest editions of IS-2848

4.4.6 RTD insulation shall be minimum class-F. Winding RTDs shall be insulated from winding voltages. Teflon insulation and sleeving near terminal box is acceptable. RTD leads shall be shielded.

4.5 **Enclosure**

4.5.1 Type of enclosure shall be as specified in the specific requirements sheet (Annexure 'A').

4.5.2 Motors shall be self-ventilated unless otherwise specified.

4.5.3 All outdoor motors shall be provided with aluminum cover (Painted) to protect it and its terminal boxes from rainwater.

4.6 **Frame, End-shields, Fans and other fabricated parts**

4.6.1 These components of the motor shall be of rigid fabricated steel, cast steel or spheroidal cast iron. In case of alternatives, specific mention of the same shall be made in the offer indicating complete chemical and physical properties of material. However, use of such material is permitted only after obtaining Purchaser's approval against a specific request of vendor for use of such alternate material.

4.6.2 Weld joints involved in fabrication of motor frame, end shields etc shall be performed according to a qualified welding procedure and shall be performed by a qualified welder.

4.6.3 Welding Procedure Specification and Performance Qualification Procedure shall be as per ASME Boiler and Pressure Vessel code Section–IX. Weld surfaces shall

be subjected to NDT as per QAP and criteria for acceptance/rejection shall be as per PP-P-2396.

4.7 **Terminal Boxes (except submersible motor pump set)**

4.7.1 For all motors, separate terminal boxes shall be provided for each of the following.

i) Stator leads
ii) Space heaters
iii) Temperature detectors
iv) Instruments

4.7.2 Terminal boxes shall be fabricated from steel plates. The stator leads shall be brought into the power terminal box as an insulated cable through a suitable insulating barrier and terminated in clamp or compression type terminals.

4.7.3 Terminal boxes shall be sealed from the motor enclosure so as to prevent entry of dust and moisture from the motor.

4.7.4 Power terminal boxes for motors above 75kW ratings shall be suitable for withstanding fault current level of 50 kA fed by the network (to which the motor is connected) for 0.25 seconds (with out any back up HRC fuses).

4.7.5 Power terminal boxes complete with cable end box for motors above 75kW ratings shall be designed and tested at system voltage and 50 kA current level to prove compliance with the following requirements of this specification:

4.7.6 Following tests shall be made: (a) A three phase, through fault current test; the test shall not result in any mechanical or electrical damage to the terminal box and (b) An internal three phase to earth short circuit test (fault is created by using appropriate size wires between three phases and earth); the test shall not result in any external damage to power terminal box other than rupturing of pressure relief device but there might be damages to the parts inside the terminal box.

4.7.7 Terminal boxes shall generally be suitable for top, bottom or side entry of cables and shall be provided with **EPDM/XLPE** gaskets on all bolted jointed to provide a degree of protection equal to IP 55. The terminal boxes shall be suitable for terminating the purchaser's cables as specified in Annexure -'A'. For single core power cables, the gland-plate shall be of non-magnetic steel.

4.7.8 Special care shall be taken in designing the terminal box for Purchaser's power cables so as to allow sufficient space for bending of cables and adequate electrical clearances. Phase to earth clearance inside the terminal box shall be minimum 25mm (after termination of purchaser's cable of specified size) and minimum

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creepage distance over the surface of bushings and surfaces resistant to tracking shall be 25mm.

4.7.9 Terminal box shall be provided with two numbers of M-12 bolts with nuts for grounding.

4.7.10 Terminals for RTDs and BTDs provided for motors located in reactor building shall be of plug-in type quick disconnecting type of connectors of approved make and type.

4.7.11 Supply and mounting of cable glands required for power and control cables are not in the scope of this specification and same shall be provided by the Purchaser. Adequate size of undrilled gland plates shall be provided to facilitate termination of cables.

4.7.12 External connections between RTDs, BTDs and other instruments to their respective terminal boxes shall be made through metallic flexible conduits. Such conduits shall be adequately supported using removable metallic clamps.

4.7.13 Instruments and accessories shall be provided with engraved labels made of aluminum and the same shall be properly fixed.

4.8 **Bearings and Bearing Housing**

4.8.1 Motor bearings shall be constructed so as to exclude dirt and water and to prevent lubricant from reaching the windings. Grease lubricated bearings shall have easily accessible grease nipples to facilitate greasing operations. The bearing assembly shall be provided with grease relief device such that when the motor runs at rated speed any surplus grease is automatically ejected out of the motor casing to a separate container.

4.8.2 Vertical motors shall be provided with single or double (as required) thrust and guide bearings.

4.8.3 Ball and roller bearings shall have a minimum calculated L10 basic rating life of 40,000 running hours and Sleeve bearings shall have a minimum life of 100,000 hours of operation, after considering (a) all the forces that normally occur and (b) seismic forces. Motor manufacturer shall obtain from the driven equipment manufacturer all necessary details required for selection of bearing and in consultation with the bearing vendor, select suitable bearings. Complete details regarding selection and technical particulars of bearings provided shall be submitted to the Purchaser after placement of order.

4.8.4 Operating temperature of bearings under all conditions shall be within the limits prescribed by the bearing manufacturer. Oil vapour (if any) generated during the

operation of motor shall be suitably collected and directed away from the windings and let out in a controlled manner to avoid any condensation on windings and fire hazard.

4.8.5 The bearings lubricating oil system shall preferably be such that no external forced oil to maintain required oil supply or water to keep bearings temperatures within design limits are necessary.

4.8.6 Bearings shall be designed to permit motor running in either forward or reverse directions as required by the driven equipment.

4.8.7 Lubricant shall be selected for prolonged storage and use of the motor in a tropical climate and shall contain corrosion and oxidation inhibitors and anti foaming agents. Grease shall have suitable bleeding characteristics to minimize setting. Data regarding suggested regreasing intervals should be furnished in the offer. In case of reactor building motors, which are required to operate following the Loss of Coolant Accident (LOCA) and, or Main Steam Line Break (MSLB), bearing lubricant shall be capable of withstanding pressure and temperature conditions prevailing at the location during and subsequent to LOCA and, or MSLB as specified so as to ensure operability of motor under these conditions.

4.8.8 When the motor shaft is not located axially by its own bearing, it shall be permanently marked to indicate its running position and the extent of float in either direction.

4.9 Balancing and Vibration

4.9.1 Vibrations in all the three directions for horizontal motors shall be within the limits specified in IS-12075. For vertical motors the measured values shall not exceed the limits at the bottom bearings. Tests for measuring amplitudes and velocity of vibration on all directions shall be carried out in the presence of Purchaser's representatives on all motors. Test data with test diagram showing amplitudes and velocity of vibration at various locations shall be submitted along with test reports.

4.9.2 Balancing of rotor with all components mounted shall be carried out at rated RPM or as permitted by the standards. Facility should be provided for trim balancing of motor at site. A chart indicating the details of balancing weights added and their locations shall be enclosed as a part of test reports. Balancing shall be to grade Gr 2.5 according to ISO 1940. Dynamic balancing of rotor for submersible motor pump set shall be as per IS 9283. Report shall be a part of Routine test reports.

4.9.3 Components such as fan, coupling etc., that are to be mounted on the shaft shall be individually balanced to enable future replacements.

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4.9.4 Weights added for the purpose of balancing shall be free of defects and shall be firmly fixed such that there is no displacement while in service.

4.10 **Grounding**

4.10.1 For all motors, a non-corrodible terminals shall be provided at two locations on the motor frame and each shall have a threaded hole of M12 size and shall be provided with suitable bolts, nuts, washers and spring washers. The threaded hole shall be of sufficient depth to ensure adequate electrical contact between external connector and motor frame. Separate earthing terminals of M12 size shall be provided for the power terminal box.

4.10.2 Gasketted joints shall be provided with metallic by pass connections of adequate size to ensure earth continuity.

4.11 **Space Heaters (except submersible & canned motor pump set)**

4.11.1 Motors shall be provided with space heaters of adequate capacity to maintain motor internal temperature above the dew point to prevent moisture condensation when the motor is not in service. The heaters shall be mounted inside the motor in accessible place so that their removal and replacement is a simple operation. Space heaters shall be rated for 240 volts, single phase, 50 cycles and shall be located in lower part of motor.

4.12 **Couplings**

4.12.1 Driven equipment manufacturer shall work out details of coupling arrangement. Motor manufacturer shall provide necessary information to the driven equipment supplier and meet the requirements of the driven equipment manufacturer.

4.13 **Direction of Rotation**

4.13.1 Direction of rotation shall be as required by the driven equipment and the same shall be indicated in drawings, documents and motor frame.

4.13.2 As specified in Annexure-A, a mechanical device to prevent reverse rotation shall be provided. The rating of mechanical reverse rotation stop shall be such that it can prevent reverse rotation when the torque in the reverse direction is not greater than 100% of rated torque of the motor in the forward direction.

4.14 **Mounting and Dowelling**

Mounting arrangement shall be matched with the requirements of the driven equipment.

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4.15 **Lifting facility**

Motors shall be provided with adequately designed eyebolts, lugs or other devices to facilitate safe lifting operations.

4.16 **Drain Plugs**

Motors shall have drain plugs to permit removal of water accumulated inside the motor.

4.17 **Base Frames**

When a motor is supplied with driven equipment having common base frame, the supplier of the driven equipment shall determine that such base frame is adequately braced to keep vibration and misalignment within permissible limits. Driven equipment supplier shall be responsible for supply of all required mounting arrangements considering the motor and driven equipment assembly.

4.18 **Name plate and Diagram of Connections**

Each motor shall have a nameplate showing all the particulars specified in relevant clause of IS-325. In addition, the nameplate shall also indicate (a) the type of bearings used for motor and the details of recommended lubricant, (b) Re-lubrication quantity & interval, (c) Limit and conditions of successive starts

5.0 **PERFORMANCE REQUIREMENTS**

5.1 **Starting Duty**:

5.1.1 The motors shall be capable of two successive restarts coupled to its driven equipment with coasting to rest between starts under both cold and hot conditions and a third restart shall be feasible after 20 minutes. The motor shall further be capable of three equally time spaced starts per hour under normal service conditions. In case of motors for cranes which are subjected to repeated starting, stopping, reversing etc., the starting duty shall be commensurate with the requirements of the driven equipment.

5.1.2 Motors shall be designed for direct on line, full voltage starting and shall withstand all stresses and give satisfactory performance when started with their driven equipment connected under all operating conditions specified for the driven equipment. The end windings of stator, and rotor shall be adequately braced and supported to cater to the different starting duty conditions. The total number of starts during the design life of motor shall be commensurate with the

requirements of driven equipment and taking into account the design life of motor.

5.1.3 Motors shall be capable to starting and accelerating the driven equipment satisfactorily at a minimum voltage of 80% of the nominal voltage at the motor terminals.

5.2 **Locked Rotor current for squirrel cage rotor**

5.2.1 For all motors (except canned and submersible pump motor set) up to & including 132kW rating, locked rotor current shall be as per particular efficiency class given in the relevant Indian Standards (tolerance as per IS). For motors above 132kW, locked rotor current shall be as given in Annexure-A.

5.3 **Fast Bus Transfer**:

5.3.1 Motors and the driven equipment shall be capable of withstanding the voltage torque stresses and forces developed due to the vector difference between the motor residual voltage and the incoming supply voltage during fast change over of the supply. The drive train of the motor and the driven equipment and motor winding shall be adequately designed to withstand mechanical forces developed during such conditions.

5.4 **Pull out:**

5.4.1 Motor shall not pull out of step when the supply voltage drops to 70% of the rated motor voltage for a short duration of 25 cycles during full load operation of motor. To meet this requirement, the pull out torque of the motor at rated voltage shall be at least 200% of full load torque.

5.5 **Over speed**:

5.5.1 Motors shall be capable of withstanding without mechanical damage, at least 120% of rated speed or as imposed by the driven equipment, whichever is higher.

5.6 **Other requirement**:

5.6.1 Motors shall be capable of satisfactory operation at full load without injurious heating when the motor terminal voltage is at 80% of rated voltage for ten minutes. Motors shall be capable of withstanding 160% rated torque for 15 and 10 seconds for normal and submersible motor pump set respectively.

5.6.2 In all cases involving typical centrifugal pumps, compressors etc. the acceleration time of motor at 80% terminal voltage shall not be greater than the locked rotor withstand time under hot condition at 100% voltage The safe stall time of the

motor shall be such that taking in to account the accelerating time of the motor with the driven equipment and specified number of hot and cold starts, adequate margin exists and the motor remains safe. The permissible stator and rotor temperatures for the purpose of calculating safe stall times shall be limited to 185^0 C and 300^0 C for stator with copper conductors insulated with class-F insulation and with aluminum die cast rotor respectively. In case of rotor with copper bars temperature limit shall be 400^0 C.

5.6.3 If called for in Annexure-A, driven equipment vendor by analysis of complete assembly of motor, coupling, driven equipment and mounting arrangements shall qualify that motor and the driven equipment assembly would continue to perform intended function during and after subjected to specified level of earthquake with out any deterioration in the performance.

5.6.4 Motors provided with power supplies from variable frequency drives shall be suitably designed and tested to take care of effects of such power supplies on motor performance.

6.0 SPARE PARTS

The supplier shall recommend spares that are required for 5 years operation and required to be stocked for maintenance purpose. However, as a minimum, supplier shall furnish prices for the following in his tender.

i) One set of complete bearing assembly for drive and non-drive end bearings
ii) One set of space heaters.
iii) Seals and other materials that require periodic replacement.
iv) Bearing & Winding RTDs, one of each type.

All the spares to be supplied should be physically and technically interchangeable with similar components already installed/in use.

7.0 INSPECTION AND TESTS

7.1 All routine tests mentioned as given in Annexure-C shall be conducted **on all motors** by the manufacturer at his work and test certificates shall be furnished to the Purchaser's representative (QA) for review & acceptance. The cost for the same shall be included in the equipment prices.

7.2 On one typical motor of each design, test reports for all type tests as given in Annexure-C shall be submitted for purchaser's review. In case type test reports are not acceptable to the Purchaser, type tests shall be performed at no extra cost to the Purchaser and without affecting the delivery period. Type test certificates shall be submitted for review and approval of the Purchaser. Type test reports

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shall not be earlier than 5 years from the date of purchase order. Any special test and or qualification tests if specified in Annexure-A, same shall be performed in accordance with approved procedure and test reports shall be submitted after qualification. Cost of type testing shall be included in the equipment prices. Price for special tests if any specified in Annexure-A shall be separately indicated and are payable only if tests are conducted and results are acceptable.

7.3 The supplier shall be responsible and shall provide for and perform all the necessary tests, compile reports, documents, arrange inspection and testing to ensure that the material, equipment and workmanship are in accordance with the stipulation detailed in the QAP attached with this specification. All inspection and test reports and reports reviewed shall form part of end documentation.

7.4 The Purchaser or his authorised representative shall at all reasonable times have access to those parts of the supplier's or sub-supplier's works concerned with the manufacture of the motor for the purpose of witnessing tests and ascertaining compliance with the requirements of this specification. The Purchaser shall also have the right to conduct at his expense any additional tests or inspection he deems necessary.

7.5 Supplier shall furnish material specification test certificates as required in the QAP and shall be in a position to co-relate these certificates with the actual material used for the motors.

7.6 After receipt of the Purchase order, the supplier shall furnish to the Purchaser a detailed schedule of manufacture and delivery to enable Purchaser's inspector to plan visits to the manufacturer's works for inspection during different stages of manufacture, which shall be as per detailed quality assurance plan attached as Annexure 'C'. The supplier will be required to develop a quality control plan in line with the requirements indicated in Annexure 'C' and submit the QAP for approval by Purchaser.

7.7 The contractor shall supply to Purchaser's representative a complete set of detailed fabrication drawings which will be used in the inspection during manufacture, which will be retained at the factory and returned after completion of the contract.

7.8 All repairs and rework shall be informed to the Purchaser and his approval taken before proceeding further. All such repair work shall be documented and where desired by the Purchaser, photographic records shall be maintained. These documents shall be included in end documents.

8.0 PAINTING AND PACKING:

8.1 The motor external parts shall be finished and painted to produce a neat and

durable surface, which would prevent rusting, and corrosion. The equipment shall be thoroughly degreased, all rust, sharp edges and scale removed. The painting system shall be having primer based on inorganic Ethyl zinc silicate (for RB motors)/zinc phosphate and compatible with epoxy paint system and top coats of epoxy paint to shade 631 of IS-5.

8.2 All materials/ spares that have limited shelf life shall be marked with expiry date in bold to indicate their storage conditions.

8.3 The motor shall be packed for dispatch to project site in strong wooden crates. The following information shall be clearly given on each box.

a) Purchaser

b) Purchaser order number

c) Equipment code number, if any.

d) List of contents of each package

e) Storage instructions

8.4 The packing should incorporate measures to prevent damage to motor winding, bearing and shaft due to jerks and shocks during transit. The packing should afford reasonable protection against ingress of rainwater.

9.0 DRAWINGS AND DOCUMENTS:

9.1 Within 4 weeks of placement of purchase order, the supplier shall furnish for Purchaser's approval following drawings:

a) Drawings showing overall dimensions and all other essential dimensions along with cross-sectional views and motor data sheets as per the format in Annexure-B.

b) Detailed drawing for terminal boxes, clearance, conductor termination, cable gland and degree of protection should also be marked on this drawing.

c) Drawing showing conductor details in slots, thickness & materials of insulation and conductor cross section should also be shown and detailed write up on the insulation system provided for the motor winding.

d) All details submitted to the driven equipment supplier for the purpose of seismic qualification of the driven equipment and the motor assembly, application check for the motor to confirm suitability of the motor to the requirements of driven equipment.

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9.2 Supplier shall take up manufacture after the Purchaser has approved the drawings.

9.3 Three prints of all drawings and documents should be submitted for approval. After execution of the order, three sets of documents/drawings in hard copies and two sets of CDs with all scanned copies of documents, drawings, data sheets, quality documents, test reports and characteristic curves shall be supplied.

9.4 Following characteristic curves shall be supplied:

9.4.1 Torque Vs speed curves for the motor superimposed with load torque vs speed characteristics.

9.4.2 Starting current Vs time and speed

9.4.3 Power factor, efficiency, load current Vs Load

9.4.4 Thermal withstand characteristics for motor under cold and Hot conditions

9.4.5 Negative sequence current capability curve

9.4.6 Residual voltage Vs time

10.0 INSTRUCTION MANUALS

10.1 Supplier shall furnish three copies of instruction manuals and two CDs with completely scanned copies of documents covering storage, installation, detailed assembly, disassembly procedures, operation and maintenance of the motors. Installation instructions shall include procedure for checking alignment of motor shaft, coupling and base. Instruction shall also cover lubricating details including recommended inspection and replacement schedules, quantity of lubricant required and specifications for the lubricant and its equivalent. Instruction manual shall include one set of all approved drawings, a complete part list, descriptive literature for all components such as Heat exchangers, RTDs, fans, filters, space heaters etc and complete details of motor in Annexure- B as per requirement.

10.2 In addition, three copies of the above instruction manual shall be supplied with each motor.

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Motor Tag Nos:
Quantity:
Project Title:

	Process Group	Electrical Design Group
Prepared by		
Reviewed by		
Approved by		

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Sl.No.	Particulars	
1.0	**SPECIAL SITE CONDITIONS**	
1.1	Type of environment (corrosive/non-corrosive)	
1.2	Location (indoors/outdoors)	
1.3	Hazardous condition	
1.4	Type of starter if any	
1.5	Whether motor is supplied from variable frequency variable voltage drives or similar such electronic drive?	
2.0	**GENERAL**	
2.1	Application/Driven equipment	
2.2	Type of motor (SCR/SR)	
2.3	Type of submersible motor pump set, (Wet Type/Resin Filled/Sealed)	
2.4	Efficiency class of motor above 132kW (IE2/IE3/any other class) (For motors up to & including 132kW, efficiency class shall be IE3)	
2.5	Nature of application of the motor (Motor is safety related / Motor is not safety related but critical / General Purpose.)	
2.6	Lower critical speed of motor	>130% of rated speed
2.7	Length of cable for submersible motor pump set, (m)	
2.8	Permissible voltage drop of 15m cable length for submersible motor pump set	≤1% of rated voltage
3.0	**RATING**	Driven equipment vendor to select the rating considering all operating conditions and provide a minimum margin of 10%
4.0	**DUTY**	
4.1	Type of duty (S1 to S8)	
5.0	**STARTING**	
5.1	Method of starting	
5.2	Number of successive starts with full load followed by next start after 20 minutes. (a) In cold condition (b) In hot condition.	 Minimum 2 Minimum 2
5.3	No. of equally spread starts per hour.	Minimum 3
5.4	Permissible starting current as % of full load current for motors above 132kW	

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	(For motors up to & including 132kW, starting current shall be as per IS)	
6.0	**INSULATION**	
6.1	Class of insulation for stator winding	Minimum Class-F
7.0	**ENCLOSURE**	
7.1	Type of enclosure.	
7.2	Degree of protection.	
7.3	Type of cooling	
8.0	**TERMINAL BOXES**	
8.1	Whether power terminal box is required to withstand 50 kA for 0.25s?, (Yes/No)	
8.2	No. of cable entries.	
8.3	Power cable size and type.	
8.4	Separate terminal box required for: Stator phase terminals, (Yes/No) Space heater terminals, (Yes/No) Winding RTD's terminals, (Yes/No) Bearing RTD's terminals, (Yes/No)	
8.5	Size of cable for space heater external connection	2.5 sq.mm Cu. conductor, 2 core HRPVC/XLPE cable or as required.
8.6	Size of cable for RTD and BTD external connection.	
8.7	Location of terminal boxes when viewed from non driving end of the motor	Left / Right / Top
9.0	**BEARINGS**	
9.1	Type of bearings	
9.2	Type of lubrication	
9.3	Expected re-lubrication interval, (Hours)	
9.4	Bearing cooling	
10	**Inspection plugs for air gap measurement required? , (Yes/No)**	
11	**Whether reverse rotation stop is required? , (Yes/No)**	
12.0	**INSPECTION, TESTING AND QUALIFICATION**	
12.1	Inspection as detailed in the specification and typical QAP attached as annexure-C required? , (Yes/No)	
12.2	Acceptance criteria for NDT as per applicable standards as follows:	

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	i)	Liquid penetrant inspection	As per PP-P-2396
	ii)	Ultrasonic inspection	As per PP-P-2012
12.3	Whether NDT specifications (PP-P-2012 & PP-P-2396) attached as a part of this tender package.		Yes/No
12.4	Whether seismic qualification of complete motor and driven equipment assembly along with all accessories and auxiliaries required to be performed? If yes, identify operability/structural integrity requirements under SSE and OBE.		<table><tr><td>Seismic Level</td><td>Structual integrity</td><td>Operability</td></tr><tr><td>SSE</td><td></td><td></td></tr><tr><td>OBE</td><td></td><td></td></tr></table>
12.5	Whether any special tests other than those indicated in the specifications / Indian Standards are required to be performed? If so, indicate details.		
13	**Special Requirements for Reactor building motors**		
13.1.	Whether motor is required to be qualified for operation during and following LOCA/MSLB? (Yes/No*)		
13.1.1	If LOCA/MSLB (accident condition) qualification is required, are the pressure and temperature transient curves enclosed? (Yes/No*)		
13.1.2	Tag number of motor required to be qualified for LOCA/MSLB		
13.1.3	Cumulative radiation dose under normal and accident conditions, (MRad)		
13.2	Whether motor insulating materials, auxiliaries, gaskets, lubricants, terminal blocks etc required to withstand radiation and operate satisfactorily? (Yes/No*)		
13.2.1	Cumulative radiation dose under normal conditions, (MRad)		
13.3	Tag number of motor for which radiation qualification is required but LOCA/MSLB qualification is not required		
13.4	Expected external over pressure likely to be experienced by motors and their accessories during reactor building pressure test.		

***** Detailed procedure shall be worked out by the Contractor and subjected to review and approval of Purchaser.

NUCLEAR POWER CORPORATION OF INDIA LIMITED	
ANNEXURE-B TO PC-E-502 FORMAT FOR SUBMISSION OF TECHNICAL PARTICULARS FOR MEDIUM VOLTAGE INDUCTION MOTORS OF CAPACITY GREATER THAN 50kW FOR 700MWe (To be filled in by Motor Manufacturer and submitted through driven equipment Manufacturer/Package Contractor)	**Project : 700MWe** **Page : 1 of 9**

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1.	Name and address of Motor Manufacturer		:	
2.	Name and address of driven equipment manufacturer		:	
3.	Name and address of Package contractor		:	
4.	References		:	
	i)	NPCIL's Purchaser Order No.	:	
	ii)	Package Contractor's Purchase Order No.	:	
	iii)	Driven Equipment Supplier's Purchase Order No	:	
	iv)	Work Order Number of Motor Manufacturer	:	
5.	NPCIL Document No.		:	
6.	Rev. No. & Date		:	
7.	Motor Tag Nos.		:	
8.	Quantity		:	
9.	Project Title		:	
10.	Contents		:	
	i)	Motor data sheets	:	Sheet 1 to 9
	ii)	Motor & load Torque v/s Speed Curves	:	Sheet 10
	iii)	Performance Curves	:	Sheet 11
	iv)	Current and speed v/s starting time	:	Sheet 12
	v)	Thermal withstand characteristics	:	Sheet 13
	vi)	Negative sequence current withstand capability curve	:	Sheet 14
	v)	Residual voltage Vs time characteristics	:	Sheet 15

	Motor Manufacturer	Driven Equipment Supplier	Package Contractor
Prepared by			
Reviewed by			
Approved by			

Motor manufacturer's name and address	**Date of issue, Rev No**

NUCLEAR POWER CORPORATION OF INDIA LIMITED	
ANNEXURE-B TO PC-E-502 FORMAT FOR SUBMISSION OF TECHNICAL PARTICULARS FOR MEDIUM VOLTAGE INDUCTION MOTORS OF CAPACITY GREATER THAN 50kW FOR 700MWe (To be filled in by Motor Manufacturer and submitted through driven equipment Manufacturer/Package Contractor)	**Project : 700MWe** **Page : 2 of 9**

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Sl. No.	Particulars		
1.0	**Guaranteed operating conditions for the motor**		
1.1	Ambient temperature, (^{0}C)		
1.2	Altitude, M		
1.3	Humidity at 40^{0}C, (%)		
1.4	Type of environment, (corrosive/non-corrosive)		
1.5	Location, (indoors/outdoors)		
1.6	Hazardous condition, (Yes/No)		
1.7	Rated voltage & its variations, (V)		
1.8	Rated frequency & its variations, (Hz)		
1.9	Permissible un-balance in supply voltage, (%)		
1.10	Permissible harmonic content in supply voltage, (%)		
1.11	Combined voltage & frequency variations, (%)		
1.12	Number of phases		
1.13	Method of system grounding.		
1.14	Seismic capability: if specified in the annexure-A, whether qualification of motor and the driven equipment assembly along with accessories and auxiliaries included in the scope of the tender? Indicate proposed method of qualification.		
1.15	Radiation withstand capability of complete motor		
1.16	Auxiliary power supply requirements		
	i)	For auxiliaries	
	ii)	For space heaters	
	iii)	For instrumentation & control	
1.17	Whether the motors are adequately designed to operate satisfactorily when supplied with power supply from electronic drives intended to be used for the driven equipment?		
2.0	**GENERAL**		
2.1	Application/Driven equipment		
2.2	Method and type of coupling to driven equipment.		
2.3	Type of motor (SCR/SR)		
2.4	Frame size		
2.5	Mounting		
2.6	Single shaft / double shaft extension.		
2.7	Direction of rotation (viewed from drive end)		
2.8	Rotation – uni /bi-directional		
2.9	Reverse rotation stop provided?		
2.10	Applicable standards/codes.		

Motor manufacturer's name and address	**Date of issue, Rev No**

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Sl. No.	Particulars		
2.11	Stator winding connection*		
2.12	Winding resistance per phase*		
3.0	**RATING**		
3.1	Rated output (kW)		
3.2	Rated speed (RPM)/Synchronous speed (RPM)		
3.3	kW actually required by the drive equipment under specified operating conditions		
4.0	**DUTY**		
4.1	Type of duty		
5.0	**STARTING**		
5.1	Method of starting		
5.2	Starting current (% of full load current)		
5.2.1	At rated voltage		
	a)	Including I.S. tolerance*	
	b)	Excluding I.S. tolerance* (Committed value)	
5.2.2	At 80% voltage		
	a)	Including I.S. tolerance*	
	b)	Excluding I.S. tolerance* (Committed value)	
5.3	Minimum voltage required for starting, (% of rated voltage)		
5.4	Starting time with DOL starting with driven equipment coupled		
	a)	At rated voltage, (sec)	
	b)	At 80% voltage*, (sec)	
5.5	Permissible No. of successive starts on full load		
5.5.1	In cold condition		
5.5.2	In hot condition.		
5.6	No. of equally spread starts per hour		
6.0	**INSULATION**		
6.1	Class of insulation for stator and rotor (in case of SR motor)		
6.2	Permissible temperature rise (by resistance method)		
	a)	Under normal conditions, (^{0}C)	
	b)	Under extreme voltage conditions (90/110% of rated voltage whichever is severe), (^{0}C)	
6.3	Tropical Treatment of motor		
6.3.1	Material of insulation		
6.3.2	Treatment of insulation, stator and rotor core for anti-fungal growth		
6.4	Radiation withstand capability of insulation system and other materials used in the motor (If specified, only for motors		

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Sl. No.	Particulars		
	located in the reactor building)		
7.0	**COSTRUCTION & MATERIALS.**		
7.1	Degree of protection provided by the enclosure		
7.2	Enclosure type (Fabricated type/ casting)		
7.3	Enclosure material grade for		
	a)	Frame	
	b)	End shields	
	c)	Power terminal box	
	d)	Bearing housing	
	e)	Gaskets	
7.4	Material for stator conductors		
7.5	Material for rotor bars, (Cu/Al)		
7.6	Material for short circuiting rings (if provided)		
7.7	Material for retaining rings (if provided)		
7.8	Heat loss to environment for the purpose of ventilation design*, (kW)		
7.9	Type of cooling		
7.10	Painting		
7.10.1	Primer (Based on Inorganic Ethyl zinc silicate/zinc phosphate compatible with epoxy paint system?), (Yes/No & Type)		
7.10.2	Finish Coats (Epoxy based?), (Yes/No, If No then indicate details)		
8.0	**TERMINAL BOXES**		
8.1	Type of main terminal Box		
8.2	Fault withstand capacity at rated voltage and its duration for		(kA)
	a)	Internal faults, (sec)	
	b)	External faults, (sec)	
8.3	Max. cable size suitable for the terminal box/Actual cable size (sqmm.)*****		
8.4	Size of T. Box (inside dimensions)*		
8.5	Degree of protection for T. Box enclosure.		
8.6	No. of cable entries.		
8.7	No. of terminals for main winding*****		
8.8	Size of connections from windings to terminals*, (sqmm & Cu/Al)		
8.9	Details of type test certificates to prove the capability of motor power terminal box to prove its capability to meet requirements stated in this specification, (NPCIL document number for Type		

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Sl. No.	Particulars		
	test report)		
8.10	Separate terminal box provided for:		
	a)	Stator phase terminals, (Yes/No)	
	b)	Rotor phase terminals, (Yes/No)	
	c)	For forming star connections, (Yes/No)	
	e)	Space heater terminals, (Yes/No)	
	f)	Winding RTD's terminals, (Yes/No)	
	g)	Bearing RTD's terminals, (Yes/No)	
8.13	Direction of cable entry		
8.14	Double compression Cable gland for T. Boxes provided? , (Yes/No)		
8.15	Size of cable gland plate suitable for		
	a)	Motor cable	
	b)	Space heater cable	
	c)	RTD cable	
8.16	Plug-in terminals for RTDs provided? , (Yes/No)		
8.17	Cable type & length for submersible motor pump set		
9	**BEARINGS**		
9.1	Type of bearing		
9.2	D.E bearing number and make.		
9.3	N.D.E bearing number and make		
9.4	Standard L10 life of bearing, (hrs)		
9.5	Type and grade of lubricant		
9.6	Quantity of lubricant required*, (grams)		
9.7	Bearing end play (mm)* Axial Radial		
9.8	Thrust bearing losses*		
9.9	Regressing interval, (hrs)		
9.10	Maximum permissible bearing temperature, (^{0}C) DE NDE		
9.11	Whether bearings are designed considering all loads expected during all operating conditions including seismic conditions (if specified) of the driven equipment?		
9.12	Whether bearings are designed for operation during and after LOCA/MSLB (only if the requirement is specified)		
10.	**ACCESSORIES**		
10.1	Temperature detectors in windings, (No. & Type)		

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Sl. No.	Particulars		
10.2	Temperature detectors in bearings, (No. & Type)		
10.3	Space – heaters		
	a)	Voltage, (V)	
	b)	Wattage/ space heater*, (W)	
	c)	Nos. proposed to be used*	
	d)	Location*	
	e)	Expected temperature of in side air above the outside ambient air temperature*, (^{0}C)	
11	**WEIGHT AND MOMENT OF INERTIA**		
11.1	Weight of stator (Kg.)*		
11.2	Weight of rotor (Kg.)*		
11.3	Total weight of motor (Kg.)*		
11.4	Shipping weight of motor (Kg.)*		
11.5	Shipping dimensions LXBXH*, (mm)		
11.6	Rotor GD^2 (Kgm^2) *		
11.7	GD^2 of driven equipment referred to motor speed (kgm^2) *		
12	**PERFORMANCE**		
12.1	Full load current (amps)		
12.2	No load current. (amps)		
12.3	Full load speed (rpm)		
12.4	No load speed (rpm)		
12.5	Efficiency At full load (%) At 75% load (%)* At 50% load (%)*		
12.6	Power factor At full load At 75% load* At 50% load*		
12.7	Noise pressure level of motor at 1.0 m at no load db (A)		
12.8	Velocity of vibration at		
	a)	No load (microns), mm/s	
	b)	With load (microns), mm/s	
12.9	Critical speed (rpm)		
	a)	Lower	
12.10	Safe stall time in secs. At 80% & 100% voltages		
	i)	When motor is at rated operating temperature	
	ii)	When motor is at ambient temp.	

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Sl. No.	Particulars		
	iii)	Limiting stator and rotor temp. considered to determine stall time, (^{0}C)	
12.11	The maximum number of starts permissible per year		
12.12	a)	Stator thermal time constant.	
	b)	Stator cooling time constant	
12.13	Overload capacity		
12.14	Torque		
12.14.1	Torque at full load		
12.14.2	Starting torque (% of full load torque) At rated voltage At 80% voltage		
12.14.3	Pull-out torque (% of full load torque) at rated voltage		
12.14.4	Pull-up torque (% of full load torque) at rated voltage		
13.0	**CONNECTIONS**		
13.1	Stator		
13.2	Number of connections brought out		
14.0	**INSPECTION**		
14.1	Customer inspection in works as specified detailed in QAP agreed?, (Yes/No)		
14.2	NDT as per applicable Annexures will be done as follows on shafts, welds etc:		
	i)	Liquid penetrant inspection, (Yes/No)	
	ii)	Ultrasonic inspection, (Yes/No)	
14.3	Welding procedure and welder qualification as specified agreed? , (Yes/No)		
14.4	Brazing procedure qualification and brazer qualification agreed for brazing of stator connections and rotor bars with end rings? , (Yes/No)		
14.5	Performance of all routine tests as specified agreed? , (Yes/No)		
14.6	Performance of all type tests as specified agreed? , (Yes/No)		
14.7	Whether full compliance to QAP attached as Annexure agreed? , (Yes/No)		
14.8	Whether full compliance to PC-E-502 and Annexure-A agreed? , (Yes/No, if No, enclose clause wise deviations)		
15.0	**DRAWINGS, CATALOGUES, DATA SHEETS**		
15.1	Descriptive pamphlets for the offered motor enclosed? , (Yes/No, If No, to be supplied along with equipment)		

Motor manufacturer's name and address	**Date of issue, Rev No**

NUCLEAR POWER CORPORATION OF INDIA LIMITED	
ANNEXURE-B TO PC-E-502 FORMAT FOR SUBMISSION OF TECHNICAL PARTICULARS FOR MEDIUM VOLTAGE INDUCTION MOTORS OF CAPACITY GREATER THAN 50kW FOR 700MWe (To be filled in by Motor Manufacturer and submitted through driven equipment Manufacturer/Package Contractor)	**Project : 700MWe** **Page : 8 of 9**

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Sl. No.	Particulars		
15.2	Details of reverse rotation stop enclosed? * , (Yes/No)		
15.3	Torque vs. speed characteristics curve at rated voltage and frequency		
	a)	For motor*, (Sheet/Drawing No. Reference)	
	b)	For driven equipment*, (Sheet/Drawing No. Reference)	
15.4	Current vs. speed characteristic curve at rated voltage and frequency during acceleration*, (Sheet/Drawing No. Reference)		
15.5	Thermal withstand characteristic curve and data in digital form for		
	a)	Hot condition*, (Sheet/Drawing No. Reference)	
	b)	Cold condition*, (Sheet/Drawing No. Reference)	
15.6	Current vs. time characteristic curve during acceleration*, (Sheet/Drawing No. Reference)		
15.7	Negative sequence current capability curve*, (Sheet/Drawing No. Reference)		
15.8	Efficiency. Power factor, speed and current vs. load characteristics*, (Sheet/Drawing No. Reference)		
15.9	Dimensional drawing showing cross sectional view and identification of components and their material specification, typical stator slot and rotor bar, shaft, fan, bearings etc*, (Sheet/Drawing No. Reference)		
15.10	Dimensional drawing of the terminal boxes showing dimensions, permissible cable size, degree of protection, type test numbers, materials of fabrication, etc and the method of terminating the purchaser's incoming cables*, (Drawing No. Reference)		
15.11	Type test certificates to prove the specified fault withstand capability of power terminal box for both (a) internal faults and (b) external faults, (NPCIL Document No. for type test report)		
16.0	**Additional Technical Particulars For Induction Motors In Reactor Building**		
16.1	Applicable standards		
16.2	Is the motor designed to operate under normal and Loss of coolant accident (LOCA) / MSLB conditions, (Normal condition/Normal and Accidental condition.)		
16.3	Capability of the motor to withstand specified radiation levels (NPCIL document no. for test certificate)		
16.4	List of materials used and their radiation withstand capability:		
16.4.1	Stator conductor, (MRad)		

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Sl. No.	Particulars	
16.4.2	Slot liner, (MRad)	
16.4.3	Slot wedge, (MRad)	
16.4.4	End connections, (MRad)	
16.4.5	Over hang portion, (MRad)	
16.4.6	Varnish for impregnation, (MRad)	
16.4.7	Gaskets, (MRad)	
16.4.8	Lubricants, (MRad)	
16.4.9	Motor terminals, (MRad)	
16.4.10	Control wires and accessories, (MRad)	
16.5	Capability of the motor to continuously operate under the specified accident conditions viz. temperature, pressure and relative humidity, (Test certificate to be submitted or type test shall be performed as per approved procedure)	

Note:

1. All data sheets and characteristic curves should be strictly in the above format in A4 and A3 size sheets respectively with continuous page numbers, properly bound and provided with a cover sheet indicating names and signatures of persons responsible for preparation, checking, approving of documents at motor manufacturer, driven equipment vendor, EPC contractor etc before submission to the Purchaser. Document shall have Purchaser's purchase order reference, EPC contractor's purchase order reference and driven equipment vendor's purchase order reference, Purchaser's project identification, Motor tag numbers, revision number, date of revision etc on the cover sheet.

2. All drawings shall be in A3 size sheets and shall indicate Purchaser's project identification, motor tag numbers, purchase order numbers etc.

3. Items marked * can be submitted after placement of order and after completion of detailed engineering.

4. The vendor shall attach sheet nos 10 to 15 referred in clause no 10 in this document or as separate document.

Motor manufacturer's name and address	**Date of issue, Rev No**

NUCLEAR POWER CORPORATION OF INDIA LIMITED

QUALITY ASSURANCE PLAN FOR 415V MOTORS OF RATING GREATER THAN 50kW

Scope and Purpose:

This document indicates the requirements expected from the package contractor/manufacturer of motors. Subsequent to the placement of Purchase Order, contractor/manufacturer shall submit for purchaser's approval a quality assurance plan in line with this document incorporating specific document numbers for "format of records", "acceptance norms" and "reference documents.If requried by the purchaser, reference documents indicated shall be shown before approval of QAP.

QAP NO: PC-E-502/Annex-C.

DATE: November, 2016

LEGEND

R: Review H: Hold P: Perform W: Witness 1: NPCIL 2: Package Contractor

3: Motor Manufacturer/External lab/Manufacturer's Sub;contractor

Manufacturer reference documents to be detailed here

AD: NPCIL Approved Document such as Tender Document, Purchase order, Drawings & Test Procedures

TR: Test Report

PS : Plant Standards

H: Customer's Hold Point (Customer is NPCIL)

W: Witness (After lapse of due notice of 2 weeks time to NPCIL, manufacturer may proceed with manufacturing/next stage)

IS: Indian Standards

IEC : International Electrotechnical Commission standards

IEEE: Institute of Electronics and Electrical Engineers standards

NOTES:

* Wherever V & W are both indicated , NPCIL QS to witness test or review TRs at NPCIL's choice.

*** TRs not more than five year old from date of purchase order may be reviewed for acceptance. Otherwise, test shall be carried out at no extra cost to NPCIL and within the committed delivery schedule.**

* Minor: The characteristic of a component, process or operation whose failure neither materially reduce the usability of the product in operation, nor does it affect the aesthetic aspects.

* Major: The characteristic of a component, process or operation whose failure may cause operation failure which cannot be readily corrected at site or cause substandard performance, increased erection and maintenance cost, reduced life or seriously affect aesthetics or ergonomics.

* Critical: The characteristics of a component, process or operation failure of which will surely cause operating failure or intermittent troubles which is difficult to rectify at site or render the unit unfit for use or safety hazards.

* ''Failure '' of a characteristic means failure to meet the 'acceptance norms '.
* Sampling: Generally in accordance with IS:2500. If 100% "witness" is carried out by "Package contractor", NPCIL will witness on sample basis, or if 100% "witness" is carried out by "Motor Manufacturer", "Package contractor" will witness on sample basis.

		QUALITY ASSURANCE PLAN 415V INDUCTION MOTORS ABOVE 50kW											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY				REMARKS
									R	P	W	H	
1	**BOUGHT OUT ITEMS**												
1.1	Enamelled, copper conductor Class F for temp. class 155 deg. C	a) Overall Dimensions	Major	Measurement	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			TC to be furnished batchwise
		b) Bare conductor dimension	Major	Measurement	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		c) Increase in dimension due to insulation coverage	Major	Measurement	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		d) Chemical composition	Major	Chemical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		e) Flexibility	Major	Mechanical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		f) Cure test	Major	Physical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		g) Electrical strength proof voltage test	Major	Electrical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		h) BDV Test at 155 deg. C.	Major	Electrical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		I) Resistivity	Major	Electrical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
1.2	Electrolytic tough pitch high conductivity copper (for rotor copper bars - if provided)	a) Tensille Strength	Major	Mechanical	1sample/ lot	PS	PS	TR	1, 2	3			TC to be furnished batchwise.
		b) Elongation	Major	Mechanical	1sample/ lot	PS	PS	TR	1, 2	3			
		c) Hardness	Major	Mechanical	1sample/ lot	PS	PS	TR	1, 2	3			
		d) Chemical Comp.	Major	Chemical	1sample/ lot	PS	PS	TR	1, 2	3			
		e) Resistivity	Major	Electrical	1sample/ lot	PS	PS	TR	1, 2	3			
		f) Free from surface defects	Major	Visual	1sample/ lot	PS	PS	TR	1, 2	3			
		g) Dimensions	Major	Mechanical	3samples /lot	Manufacturing Drgs.	Manufacturing Drgs.	TR	1, 2	3			
		h) DP test	Major	NDT	3samples /lot	PP-P-2396	PP-P-2396	TR	1, 2	3			

		QUALITY ASSURANCE PLAN 415V INDUCTION MOTORS ABOVE 50kW											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY R	AGENCY P	AGENCY W	AGENCY H	REMARKS
1.3	Forged Short circuting ring. (if copper rotor bars are provided)	a) Chemical comp.	Major	Chemical	1sample/ lot	PS	PS	TR	1, 2	3			TC to be furnished batchwise.
		b) Tensile strength	Major	Mechanical	1sample/ lot	PS	PS	TR	1, 2	3			
		c) Elongation	Major	Mechanical	1sample/ lot	PS	PS	TR	1, 2	3			
		d) Conductivity	Major	Electrical	1sample/ lot	PS	PS	TR	1, 2	3			
		e) Dimensions	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	TR	1, 2	3			
		f) Visual inspection of cracks and blow holes	Major	Visual	100%	PS	PS	TR	1, 2	3			
		g) DP test	Critical	NDT	100%	PP-E-1209	PP-E-1209	TR	1, 2	3			
1.4	Insulating Material/Tapes	a) Dimensions	Major	Measurement	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			TC to be furnished batchwise.
		b) Chem. comp.	Major	Chemical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		c) Heat aging test	Major	Thermal	1sample/ lot	IS/PS	IS/PS	TR	1,2	3			
		d) BDV	Major	Electrical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
1.5	Impregnating Varnish / Resins	a) Packing viscosity	Major	Measurement	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			TC to be furnished batchwise.
		b) Non volatile content	Major	Chemical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		c) Drying in thin layer	Major	Measurement	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		d) Curing in thick layer	Major	Measurement	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		e) Stability of varnish/resin in open vessel	Major	Measurement	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		f) Effect of varnish on enamelled copper wire	Major	Measurement	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		g) Electric strength at 155 deg. C.	Major	Electrical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		h) Electric strength at Room Temperature	Major	Electrical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		i) Volume resistivity	Major	Measurement	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			

		QUALITY ASSURANCE PLAN 415V INDUCTION MOTORS ABOVE 50kW											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY				REMARKS
									R	P	W	H	
1.6	Shaft material	a) Chemical comp.	Major	Chemical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		b) Hardness	Major	Mechanical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		c) Yield strength	Major	Mechanical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		d) Tensile strength	Major	Mechanical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		e) Elongation	Major	Mechanical	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		f) Grain size	Major	Measurement	1sample/ lot	IS/PS	IS/PS	TR	1, 2	3			
		g) Ultrasonic test	Critical	NDT	100%	PP-P-2012	PP-P-2012	TR	1	3	2		
1.7	Stamping Steel material	a) Specific core loss	Major	Electrical	1sample / lot	IS/PS	IS/PS	TR	1,2	3			TC to be furnished batchwise.
		b) Magnetisation (Permeability)	Major	Electrical	1sample / lot	IS/PS	IS/PS	TR	1, 2	3			
		c) Insulation resistance	Major	Electrical	1sample / lot	IS/PS	IS/PS	TR	1, 2	3			
		d) Stacking factor	Major	Mechanical	1sample / lot	IS/PS	IS/PS	TR	1, 2	3			
		e) Type of coating	Major	Mechanical	1sample / lot	IS/PS	IS/PS	TR	1, 2	3			
		f) Thickness	Major	Measurement	1sample / lot	IS/PS	IS/PS	TR	1, 2	3			
		g) Thickness of coating	Major	Measurement	1sample / lot	IS/PS	IS/PS	TR	1, 2	3			
1.9	Steel plates (For stator frames and end shields)	a) Thickness	Major	Measurement	1sample / lot	Mfg Drg	Mfg Drg		1.2	3			TC to be furnished batchwise.
		b) Chemical comp.	Major	Chemical	1sample / lot	IS/PS	IS/PS	PS	1.2	3			
		c) Tensile strength	Major	Mechanical	1sample / lot	IS/PS	IS/PS	PS	1.2	3			
		d) Yield strength	Major	Mechanical	1sample / lot	IS/PS	IS/PS	PS	1.2	3			
		e) Elongation	Major	Mechanical	1sample / lot	IS/PS	IS/PS	PS	1.2	3			
1.10	Stator frame and end shields - Castings	a) Dimensions	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	TR	1, 2	3			
		b) Chemical comp.	Major	Measurement	100%	IS/PS	IS/PS	TR	1, 2	3			
		c) Mechanical Properties.	Major	Measurement	100%	IS/PS	IS/PS	TR	1, 2	3			
		d) Casting Quality	Critical	Visual	100%	IS/PS	IS/PS	TR	1, 2	3			

		QUALITY ASSURANCE PLAN 415V INDUCTION MOTORS ABOVE 50kW											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY				REMARKS
									R	P	W	H	
1.11	Fans (fabricated)	a) Dimensions	Major	Measurement	100%	IS/PS	IS/PS		1, 2	3			
		b) Visual check	Major	Visual	100%	IS/PS	IS/PS	TR	1, 2	3			
		c) D.P. test on major weld joints (as per drawing)	Critical	NDT	100%	PP-P-2396	PP-P-2396	TR	1	3	2		
1.12	Bearing housings	a) Visual checks	Major	Visual	100%	IS/PS	IS/PS	TR	1	3			
		b) Dimensions	Major	Measurement	100%	IS/PS	IS/PS	TR	1	3			
		c) DP test on load bearing surfaces	Critical	NDT	100%	PP-P-2396	PP-P-2396	TR	1	3	2		
1.13	Power Terminal Box	a) Visual check	Major	Visual	100%	Test Report	Test Report	TR	1	3	2		Review of type test report.
		b) Review of type test reports	Major	Review	Sample	Test Report	Test Report	PS	1, 2	3		1	
		c) Compliance to type tested terminal boxes	Major	Review	Sample	Test Report	Test Report	PS	1, 2	3		1	
1.14	RTD & BTD	a) Temperature calibration	Major	Measurement	1sample /lot	IS/PS	IS/PS	TR	1,2	3			
		b) Dimension	Major	Measurement	1sample /lot	IS/PS	IS/PS	TR	1,2	3			
		c) Accuracy	Critical	Measurement	1sample /lot	IS/PS	IS/PS	TR	1,2	3			
		d) HV test	Major	Electrical	1sample /lot	IS/PS	IS/PS	TR	1, 2	3			
1.15	Space heaters	a) Verification of name plate details	Minor	Visual	100%	IS/PS	IS/PS		1, 2	3			
		b) High voltage test	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
		c) Insulation resistance measurement	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			

		QUALITY ASSURANCE PLAN 415V INDUCTION MOTORS ABOVE 50kW											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY				REMARKS
									R	P	W	H	
2	**INPROCESS INSPECTION**												
2.1.1	Fabricated / Cast frame/end shields	a) Blow holes/cracks	Major	Visual	100%	IS/PS	IS/PS	TR	1, 2	3			Welding to be done by Manufacturer qualified welders based on qualified procedures.
		b) Stress relieving	Major	Physical	100%	IS/PS	IS/PS	TR	1, 2	3			
		c) D.P. Test on weld joints of load bearing areas (as per the drawing)	Critical	NDT	100%	PP-P-2396	PP-P-2396	TR	1	3	2		
		d) Dimensions	Major	Measurement	100%	IS/PS	IS/PS	TR	1, 2	3			
2.1.2	Machined frame and endshields.	a) Surface finish	Major	Visual	100%	IS/PS	IS/PS	TR	1, 2	3			Welding to be done by Manufacturer qualified welders based on qualified procedures.
		b) Measurement of run out/concentricity/PCD	Critical	Measurement	100%	IS/PS	IS/PS	TR	1, 2	3			
		c) D.P. Test on load bearing areas (as per drawing)	Critical	NDT	100%	PP-P-2396	PP-P-2396	TR	1	3	2		
		d) Dimensions	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	TR	1	3			
2.1.3	Machined bearing housing	a) Surface finish	Minor	Visual	100%	IS/PS	IS/PS	TR	1, 2	3			
		b) Dimensions	Minor	Visual	100%	Manufacturing Drgs.	Manufacturing Drgs.	TR	1, 2	3			
2.2	Rotor												

		QUALITY ASSURANCE PLAN 415V INDUCTION MOTORS ABOVE 50kW											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY				REMARKS
									R	P	W	H	
2.2.2	Machined Shaft	a) Dimensions	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	TR	1, 2	3			
		b) Surface finish	Major	Visual	100%	IS/PS	IS/PS	TR	1, 2	3			
		c) D.P. Test on load bearing areas and shaft extension	Major	NDT	100%	PP-P-2396	PP-P-2396	TR	1	3	2		
2.2.3	Die Cast aluminum Rotor (for die cast rotors only)	a) Blow holes/cracks	Major	Visual	100%	IS/PS	IS/PS	TR	1, 2	3			
		b) Chemical Composition	Major	Chemical	1sample /lot	IS/PS	IS/PS	TR	1, 2	3			
2.2.4	Brazed Rotor (for Copper rotors only)	a) D.P. Test on brazed joints	Critical	NDT	100%	PP-P-2396	PP-P-2396	TR	1	3	2		Brazing to be done by qualified brazers based on qualified procedures.
2.2.5	Rotor assembly complete	a) Major dimensions	Major	Measurement	100%	IS/PS	IS/PS	TR	1, 2	3			
		b) Dynamic balancing of rotor	Critical	Measurement	100%	IS/PS	IS/PS	TR	1, 2	3			
		c)Runouts on bearing step and shaft extension	Major	Measurement	100%	IS/PS	IS/PS	TR	1, 2	3			
2.3	STATOR							PS					
2.3.1	Stator Coils	a) Dimension checks	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	TR	1.2	3			
		b) No. of turns	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	TR	1, 2	3			
		b) Visual check	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
		c) Inter turn test (Surge Comparison	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
2.3.2	Stator core (Before coil insertion)	a) Core length	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	TR	1.2	3			
		d) Visual check	Major	Visual	100%	IS/PS	IS/PS	TR	1, 2	3			
2.3.3	Wound Stator (before impregnation)	a) Visual check	Major	Visual	100%	IS/PS	IS/PS	TR	1, 2	3			

		QUALITY ASSURANCE PLAN 415V INDUCTION MOTORS ABOVE 50kW											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY				REMARKS
									R	P	W	H	
		b) Resistance	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
		c) Insulation resistance	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
		d) Placement of RTD's	Major	Visual	100%	IS/PS	IS/PS	TR	1, 2	3			
		e) IR and resistance of RTD's	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
		f) Interturn voltage test	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
		g) HV test	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
		h) Bracing of wdg. Overhang	Major	Visual	100%	IS/PS	IS/PS	TR	1, 2	3			
2.3.4	Impregnation (VPI)	Process parameters	Major	Visual	100%	IS/PS	IS/PS	TR	1, 2	3			
2.3.5	Wound stator (after impregnation)	a) Resistance	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
		b) Insulation resistance	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
		c) HV test	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
		d) Polarity	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
		e) IR, resistance & HV test on RTD's	Major	Electrical	100%	IS/PS	IS/PS	TR	1, 2	3			
3	**TESTS**												
3.1	Completed Motor	a) Air Gap	Major	Measuring stator ID and rotor OD	100%	Manufacturing Drgs.	Manufacturing Drgs.	Test Report		3	1, 2		1 sample/rating shall be witnessed by 1, 2
		b) Mounting and over all diemensions including TB	Major	Mechanical	100%	Approved GA Drg.	Approved GA Drg.	Test Report		3	1, 2		
		c) Runout of shaft extension, spigot and flange	Major	Mechanical	100%	Approved GA Drg.	Approved GA Drg.	Test Report		3	1, 2		

		QUALITY ASSURANCE PLAN 415V INDUCTION MOTORS ABOVE 50kW											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY				REMARKS
									R	P	W	H	
3.2	Routine Tests	a) IR of winding before and after HV test	Major	Electrical	100%	IS/PS	IS/PS	Test Report		3	1, 2		
		b) HV test	Major	Electrical	100%	IS/PS	IS/PS	Test Report		3	1, 2		
		c) Resistance measurement	Major	Electrical	100%	IS/PS	IS/PS	Test Report		3	1, 2		
		d) IR, HV on space heater and winding RTD	Major	Electrical	100%	IS/PS	IS/PS	Test Report		3	1, 2		
		e) Phase sequence & direction of rotation	Major	Electrical	100%	IS/PS	IS/PS	Test Report		3	1, 2		
		f) Locked rotor test	Major	Electrical	100%	IS/PS	IS/PS	Test Report		3	1, 2		
		g) Reduced voltage running test on no load	Major	Electrical	100%	IS/PS	IS/PS	Test Report		3	1, 2		
		h) No load test	Major	Electrical	100%	IS/PS	IS/PS	Test Report		3	1, 2		
		i) Completeness along with dimensional checks	Major	Visual	100%	Approved GA Drg.	Approved GA Drg.	Test Report		3	1, 2		
		j) Vibration test	Major	Electrical	Similar motor	IS/IEC	IS/IEC	Test Report		3	1, 2		
		k) Terminal marking and rating plate details	Major	Visual	100%	Approved GA Drg.	Approved GA Drg.	Test Report		3	1, 2		
3.3	Type Tests (In addition to all tests mentioned in routine test)	a) Temp. rise test at approx + 10% or -10% of rated voltage, whichever is severe	Major	Electrical	Similar motor	IS/IEC	IS/IEC	Test Report		3	1, 2		Test to be perofmed only if suitable type test certificate for identical motor design is not available. If test is conducted, the same shall be offered for witness by 1, 2.
		b) Temp. rise test at rated voltage	Major	Electrical	Similar motor	IS/IEC	IS/IEC	Test Report		3	1, 2		
		b) Load test and derivation of performance data corresponding to 50%, 75% and 100% load at rated voltage	Major	Electrical	Similar motor	IS/IEC	IS/IEC	Test Report		3	1, 2		
		c) Operation of motor on full load at 70% voltage 10 sec. & 80% voltage for 10 min.	Major	Electrical	Similar motor	AD	AD	Test Report		3	1, 2		
		d) Test for degree of protection by enclosures of motor and terminal boxes	Major	Mechanical	Similar motor	IS/IEC	IS/IEC	Test Report		3	1, 2		
		e) Noise level	Major	Electrical	Similar motor	IS/IEC	IS/IEC	Test Report		3	1, 2		
		f) Vibration test	Major	Electrical	Similar motor	IS/IEC	IS/IEC	Test Report		3	1, 2		
		g) Overspeed test	Major	Electrical	Similar motor	IS/IEC	IS/IEC	Test Report		3	1, 2		

		QUALITY ASSURANCE PLAN 415V INDUCTION MOTORS ABOVE 50kW											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY R	AGENCY P	AGENCY W	AGENCY H	REMARKS
		h) Starting current & starting torque at reduced voltage	Major	Electrical	Similar motor	IS/IEC	IS/IEC	Test Report		3	1, 2		
		i) Momentary overload test	Major	Electrical	Similar motor	IS/IEC	IS/IEC	Test Report		3	1, 2		
		j) Review/approval of all type test reports	Major	Review	100%	Test Report	Test Report	Test Report	1, 2	3		1	
4.0	Pre despatch Inspection	a) Painting finish	Major	Visual	100%	Approved GA Drg.	Approved GA Drg.	TR		3	1, 2		
		b) Review of end documents & issue of shipping release	Major	Review of all doc. For each motor	100%	Approved documents	Approved documents	TR		3	1, 2	1	
5.0	If specified in Annexure-A, special tests required to demonstrate capability of motors to perform in the anticipated ambient conditions due to radiation, LOCA and MSLB, shall be performed in accordance with an approved procedure and reports submitted to NPCIL.												

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1.0 SCOPE

This specification covers the technical requirements for design, manufacture, inspection, testing, supply and guarantee of High Voltage induction Motors.

2.0 CONTENTS

For table of contents, refer sheet number 4 of this specification.

3.0 STANDARDS

The motors shall conform to the latest editions of the following standards unless specified otherwise in this specification.

IEC	60034 (All Parts)	:	Rotating Electrical Machines
IS	14578	:	Three-phase induction motors for use in nuclear power plants - Specification

In case of conflicts, requirements stated in this specification shall govern.

4.0 OPERATING CONDITIONS

4.1 Motors shall be suitable for continuous operation under the following operating conditions:

1.	Ambient temperature at the location of motor	50^0 C
2.	Cooling water at inlet to the motor cooling system	37^0 C
3.	Site altitude	Less than 1000mtrs
4.	Humidity	90% at 40^0 C
5.	Rated voltage and its variation	6.6kV+/-10%
6.	Rated frequency and its variation	50Hz+/-5%
7.	Number of Phases	3
8.	Combined variation	10%
9.	Unbalance in supply voltage	3%
10.	Harmonics in the supply voltage	5%
11.	Method of power supply system grounding	Non-Effectively grounded system.
12.	Power supply voltages for auxiliaries	(a) 240V AC, 50Hz, 1-Phase for space heater. (b) 240V AC, 50Hz, 1-Phase or 24V

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		DC for instrumentation and Controls.
13.	Permissible total Temperature of motor windings under normal operating conditions of voltage and frequency, ambient temperature and coolant water specified in serial no 4.1(1) and 4.1(2) above. Measured by winding resistance	120^0 C
14.	Permissible total Temperature of motor windings under extreme conditions of voltage and frequency and coolant water specified in serial no 4.1(1) and 4.1 (2) above. Measured by winding resistance	130^0 C
15.	Seismic requirements	If specified in annexure-A, total assembly consisting of motor and driven equipment shall be qualified and documented to prove its capability to withstand specified seismic accelerations.
16.	Radiation dose for which motors located inside the reactor building required to be designed.	As specified in Annexure-A.
17.	External Over pressure for motors inside reactor building during reactor building Pressure test.	Motors and their auxiliaries shall withstand satisfactorily external pressure specified in Annexure-A

5.0 DESIGN REQUIREMENTS

5.1 General:

5.1.1 Motors shall be designed, manufactured, inspected, tested and equipped with accessories in accordance with this specification, and details furnished in attached Annexure-A, Annexure-C and the applicable standards. Materials and components not specifically stated in this specification and which are necessary for meeting the operational and or performance requirements of this specification should be included in the scope of supply. Any special tools

and tackles required for assembly, disassembly and maintenance of motor are deemed to be included in the scope of supply.

5.1.2 Design and manufacture of the motors shall be coordinated with the requirements of the driven equipment. The motor manufacturer shall co-operate fully with the Purchaser and the manufacturer of the driven equipment by furnishing required information for proper assembly and operation of the unit as a whole and to offer a motor suitable for the driven equipment duty and application. Typically, the details that may have to be exchanged between the driven equipment vendor and the motor vendor would include:

i) A copy of this specification (including Annexure-A), Load Torque vs Speed characteristics, load GD^2, rated speed, number of starts/restarts, operating duty, load on bearings, mounting, provisions to be made by the motor vendor for ensuring proper coupling, instrumentation, location etc and specific mechanical requirements such as provision of fly wheel, shaft, brake, anti reverse rotation device, cooling circuit etc.

ii) A fully dimensioned outline drawing of the motor, shaft, mounting details and motor terminal box arrangement, handling and transport arrangement, maintenance specification.

iii) Technical particulars and characteristic curves as asked in Annexure 'B' of this specification.

iv) If specified, submitting all details that are required by agency performing seismic analysis of motor and the driven equipment as a single unit.

5.1.3 When motors are purchased with the driven equipment, driven equipment supplier shall be responsible to the Purchaser for coordinating with the motor manufacturer for supply of required motors and accessories as per this specification and for satisfactory operation of complete unit.

5.1.4 Where the quantity is more than one, similar parts shall be physically and technically interchangeable between the motors.

5.2 **Rotor:**

5.2.1 The rotor design shall provide a rigid cage construction with copper bars firmly wedged in bar slots and solidly bonded to the copper end rings (wherever provided). The end ring assembly shall be such that it is free to

move with the expansion of the bars without distortion. The rotor cage shall be designed to operate satisfactorily under specified repetitive starting and load cycles. The rotor end lamination shall be rigidly fixed to prevent flaring.

5.2.2 Rotor bars shall be made of either electrolytic tough pitch high conductivity copper bars or copper silicon bars. Final material selection for rotor bar and rotor shaft shall be the responsibility of manufacturer to meet specification, testing and performance requirements.

5.2.3 Rotor shaft shall be of forged material. The shaft shall be ultrasonically tested and after final machining, it shall be dye penetrant tested. Ultrasonic, dye penetrant and radiographic examination shall be as per approved NPCIL procedures which shall be submitted to successful bidder. Acceptance norms for defects in shafts shall be as per the approved NPCIL procedures.

5.2.4 Rotor bars shall be brazed to the end rings by qualified brazers using qualified brazing procedure in accordance with acceptable standards for brazing.

5.2.5 Retaining rings, if used, shall be forged material. Forging shall be subjected to ultrasonic and dye penetrant testing as per approved NPCIL procedure.

5.2.6 The complete drive train assembly consisting of motor rotor assembly, coupling, driven equipment and all other attachments shall be designed, and demonstrated by documentation regarding adequacy to withstand instantaneous torque resulting due to fast auto bus transfer at the supply system feeding the motors. Refer to clause 5.3 of this specification.

5.3 Stator

5.3.1 Motor shall be insulated to minimum class ‘F’ insulation with temperature rise limited to class B. The insulation system shall be of proven design and shall have high dielectric strength, high mechanical strength and long life. Manufacturer shall select appropriate insulation material of high quality to make overall insulation system to meet specified class of insulation and expected life. Use of following insulation material for stator conductor is suggested:

a) Conductor inter-turn, slot & overhang insulation – Glass/polyester baked mica paper tape bonded with epoxy resin.
b) Slot corona protection material – Graphite loaded non woven polyester tape.
c) End corona protection material outside stator core – Silicon carbide loaded paint or tape.

d) Finishing tape on coil overhang – Glass/polyester high shrink tape with anti-tracking properties.
e) Impregnation of stator core pack – Epoxy-polyester resin

5.3.2 The insulation system of the motor shall be vacuum pressure impregnated (VPI). The whole assembly of stator winding and overhang shall be vacuum impregnated in resin, pressurized and heat cured.

5.3.3 Supplier shall describe insulation and insulation treatment and its capacity to meet the operating requirements specified. Details shall be submitted along with datasheet.

5.3.4 Motor core and winding shall be given tropical and fungicidal treatment for protection against (a) tropical weather conditions (b) fungus growth and moisture (c) oil (d) abrasive and conducting dust and chemical fumes that are likely to be encountered in and around the power plant area. For this purpose manufacturer shall provide non-hygroscopic & non-digestible (to fungus/mold) insulation material and suitable measures.

5.3.5 Motor insulation of oil lubricated motors shall be designed to operate satisfactorily when exposed to oil vapour and, or oil leaks on to the stator winding.

5.3.6 Insulation at joints in the motor winding such as at coil connection etc shall be insulated to the same level as that of complete motor. Additionally, joints should have minimum resistance and mechanically strong. Joints shall be braced to withstand various stresses likely to encounter during their service. Joints in stator winding conductors shall be brazed in accordance with a qualified brazing procedure and a qualified brazer shall perform brazing. The brazing procedure and brazer qualification shall be performed in accordance with acceptable standards for brazing.

5.3.7 Overhang portion shall be adequately braced to withstand forces due to repeated restarts and voltage conditions due to fast bus transfer. Supports for the overhang portion shall be of non-magnetic material.

5.3.8 Insulation system for the motor shall be designed to withstand satisfactorily without any deterioration the voltage surges produced due to chopping of currents by circuit breakers controlling the motors. Suppliers shall indicate clearly the level of inter-turn insulation provided. Suppliers shall furnish type test report and carry out impulse withstand voltage tests and switching surge tests for main and inter-turn insulation as per applicable standards. Further, complete winding of all motors shall also be subjected to tan delta and delta tan delta measurements and one motor of each type shall also subjected to measurement of tan delta and delta tan delta at elevated temperatures.

5.3.9 Motors located inside the reactor building shall be provided with insulation systems, terminal supports, lead wires, control wiring, connectors, terminal blocks, gaskets, seals, lubricating oil or grease etc capable of withstanding specified radiation dose during its service life including accident conditions if any, as specified in annexure-A.

5.3.10 Stator windings shall be of insulated copper conductors.

5.4 **Resistance Temperature Detectors (RTD)**

5.4.1 Motors shall be provided with minimum of 4 RTDs per phase suitably distributed in the winding and terminated in a separate terminal box through an intermediate terminal box if required.

5.4.2 2-wire simplex type RTD for PCP motor and 5-wire simplex type RTD for all other motors shall be recommended.

5.4.3 One 4-wire, duplex RTD shall be embedded in each bearing respectively for all other motors except PCP. For PCP, two numbers of 2-wire simplex RTD shall be embedded in each bearing respectively.

5.4.4 RTDs shall be platinum, having a D.C. resistance of 100 ohms at 0 Deg.C.

5.4.5 The RTDs shall comply with the latest editions of IS-2848

5.4.6 RTD insulation shall be minimum class-H and tolerance as per class-B. RTDs shall be insulated from HV winding and its lead shall be shielded. The insulation and shield shall prevent high voltage in event of short circuit between HV windings and RTDs.

5.5 **Enclosure**:

5.5.1 Type of enclosure shall be as specified in the specific requirements sheet (Annexure ‘A’).

5.5.2 The type of cooling of the motor shall be as specified in Annexure ‘A’ of the specification.

5.6 **Frame, End-shields, Fans and other fabricated parts**:

5.6.1 These components of the motor shall be of rigid fabricated steel, cast steel or spheroidal cast iron. In case of alternatives, specific mention of the same

shall be made in the offer indicating complete chemical and physical properties of material. However, use of such material is permitted only after obtaining Purchaser's approval against a specific request of vendor for use of such alternate material.

5.6.2 Steel plates used for stator frame, end shield etc having thickness more than 25 mm shall be subjected to Ultrasonic testing.

5.6.3 Weld joints involved in fabrication of motor frame, end shields etc shall be performed according to a qualified welding procedure and shall be performed by a qualified welder.

5.6.4 Welding Procedure Specification and Performance Qualification Procedure shall be as per ASME Boiler and Pressure Vessel code Section –IX. Weld surfaces shall be subjected to NDT as per QAP and criteria for acceptance/rejection shall be as per approved NPCIL procedures.

5.7 **Terminal Boxes:**

5.7.1 Motors shall have separate terminal boxes provided for each of the following:

i) Stator leads
ii) Space heaters
iii) Temperature detectors
iv) Neutral terminal boxes, where specified.
v) Instruments

5.7.2 Terminal boxes shall be fabricated from steel plates. The power terminal box shall be of phase segregated construction with metallic barrier between the phases. The stator leads shall be connected to terminal bushings by insulated cable through a suitable insulating barrier and terminated using clamp or compression type terminals. The terminal bushing shall be suitable for 6.6kV resistance earthed system and all technical details of bushings as per applicable standard shall be submitted in technical datasheet. The creepage distance over the bushings of hermetically sealed motors for chillers shall not be less than 31mm/kV.

5.7.3 Terminal boxes shall be sealed from the motor enclosure so as to prevent entry of dust and moisture from the motor. In case of hermetically sealed chiller motors, suitable thermal insulation shall be provided to ensure that the temperature of the terminal box is not below the ambient temperature.

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5.7.4 The phase segregated metallic barriers shall be earthed within the power terminal box for all the compartments. For smaller motors of 400kW and below, insulated barriers between different phase compartments can also be accepted, if it qualifies short circuit test as given in this specification.

5.7.5 Power terminal box shall be suitable for withstanding the through fault current level of 44 kA fed by the network (to which the motor is connected) for 0.25 seconds (without any back up HV HRC fuses).

5.7.6 Power terminal box complete with cable end box shall be designed and tested at NABL accredited test laboratory to prove compliance with the following requirements of this specification:

5.7.6.1 The following tests shall be made:

(a) A three phase, through fault current test at 44 kA rms and 100 kA peak for 0.25 seconds. The test shall not result in any mechanical or electrical damage to the terminal box and terminals.

(b) A three phase short-circuit test at 500MVA (either at 6.6kV, 44kA, for 0.25 seconds or at 11kV, 40kA, for 0.2 seconds) for air insulated and phase insulated power terminal boxes. The test shall not result in any external damage other than rupturing of pressure relief device. However, parts inside the terminal box may be damaged during the test.

(c) A single phase to earth short circuit test (either at 6.6kV, min. 2000A, for 0.25 seconds or at 11kV, min. 2000A, for 0.2 seconds); the test shall not result in any damage to power terminal box other than rupturing of pressure relief device. For phase segregated power terminal boxes, this test shall not result in spread or propagation of the fault to or between the other two phases, which are to be at rated potential for the test.

5.7.7 Terminal boxes shall be suitable for bottom entry of cables for motors located in Reactor Building and for top and bottom entry of cables for all other areas. Terminal boxes shall be provided with **EPDM** rubber gaskets (or approved equivalent) on all bolted joints to provide a degree of protection equal to IP 55. The terminal boxes shall be suitable for terminating the purchaser's cables as specified in Annexure 'A'. The terminal box for neutral and stator leads shall be of the detachable type. For single core power cables, the gland-plate shall be of non-magnetic steel.

5.7.8 Minimum distance between power terminals and gland plate for main PSTB shall be kept at 650mm for installation of HV cables termination kit.

5.7.9 Special care shall be taken in designing the terminal box for Purchaser's power cables so as to allow sufficient space for bending of cables and adequate electrical clearances. Phase to earth air clearance inside the terminal

box shall be minimum 63mm and minimum creepage distance over the surface of bushings and surfaces resistant to tracking shall be 90mm. Lower clearance/distance is acceptable for impulse tested terminal boxes, subject to review and approval by Purchaser.

5.7.10 All terminals, connectors, cables and conductors whether in a terminal box or otherwise, shall be fully insulated with no bare live parts. The design shall be such as to enable ready disconnection of motor from its supply cable to permit separate testing of the supply cable or motor windings.

5.7.11 The cables from the cable gland to the terminals or connectors and terminal leads from these terminals or connectors to the windings, for a distance of 150 mm beyond their point of entry in to the motor frame, shall be adequately braced to withstand the forces produced by maximum fault current (44 kA) and shall have copper conductor of cross section to give not more than 0.403 kA /mm^2 current density, under such condition.

5.7.12 In addition to above, power terminal box for hermetically sealed chiller motors should be provided with space heaters, porcelain bushings, silica gel breather assembly etc so as to prevent moisture condensation inside the terminal box and consequent flashover during the service period of motors. Details shall be submitted at the time of offer and subjected to approval of Purchaser. These motors shall be supplied with cable terminals and 6.6kV cable termination kits which would facilitate complete encasement of all live metallic parts inside the terminal box with removable insulating system of approved make and type.

5.7.13 Whenever specified in datasheet ‘A’, separate terminal box shall be provided for the neutral leads of the stator. As specified in annexure ‘A’, the motor manufacturer shall provide CTs for differential protection of motor in this terminal box. Specifications for CTs will be given by the Purchaser (after the placement of order) to enable the supplier of motor to supply and install CTs. CT secondary leads shall be brought out to separate terminal box provided with short circuiting type terminal blocks.

5.7.14 Terminal box shall be provided with two numbers of M-12 bolts (or of appropriate size concurred by Purchaser) with nuts for grounding.

5.7.15 Terminals for RTDs and BTDs and other instruments and auxiliaries shall be of plug-in type quick disconnecting type of connectors of approved make and type.

5.7.16 Supply and mounting of cable glands required for power and control cables are not in the scope of this specification and same shall be provided by the

Purchaser. Adequate size of undrilled gland plates shall be provided to facilitate termination of cables.

5.7.17 Wiring from RTDs, CTs, instruments, space heaters, BTDs etc including instruments if any free issued for the motor by NPCIL, to their respective terminal boxes shall be routed through metallic flexible conduits adequately supported on removable type of clamps on the motor body.

5.7.18 All instruments shall be provided with identification numbers inscribed on aluminum tags and firmly fixed.

5.8 **Bearings and Bearing Housing**:

5.8.1 Motor bearings shall be constructed so as to exclude dirt and water and to prevent lubricant from reaching the windings. Grease lubricated bearings shall have easily accessible grease nipples to facilitate greasing operations during standstill and motor running condition. The bearing assembly shall be provided with grease relief device such that when the motor runs at rated speed any surplus grease is automatically ejected out of the motor casing to a separate container.

5.8.2 Vertical motors shall be provided with single or double (as required) thrust and guide bearings.

5.8.3 Ball and roller bearings shall have a minimum calculated L10 basic rating life of 40,000 running hours and Sleeve bearings shall have a minimum life of 100,000 hours of operation, after considering (a) all the forces that normally occur and (b) seismic forces. Motor manufacturer shall obtain from the driven equipment manufacturer all necessary details required for selection of bearing and in consultation with the bearing vendor, select suitable bearings. Complete details regarding selection and technical particulars of bearings and its cooling arrangement provided shall be submitted to the Purchaser after placement of order.

5.8.4 Operating temperature of bearings under all conditions shall be within the limits prescribed by the bearing manufacturer. Oil vapour generated during the operation of motor shall be suitably collected and directed away from the windings and let out in a controlled manner to avoid any condensation on windings and fire hazard.

5.8.5 The bearings lubricating oil system shall preferably be such that no external forced oil to maintain required oil supply or water to keep bearings temperatures within design limits are necessary. Oil lubrication system shall have oil tank for automatic gravity flow along with required oil level indicator and oil level switch. However, when forced oil lubrication is essential, the design and operation of the system shall include all instruments

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(Dial type thermometer with alarm and trip contacts, oil level indicator etc.,) to monitor conditions, provide annunciation and to provide interlocks to prevent inadvertent operation of bearings without adequate lubrication.

5.8.6 Bearings shall be designed to permit motor running in either forward or reverse directions as required by the driven equipment.

5.8.7 Bearings shall be provided with suitable insulation at one end to avoid circulating shaft currents for horizontal motors. Wherever provided all oil and water pipes, direct driven oil pumps etc shall be insulated where necessary to prevent a return path through the bearings for motor shaft currents.

5.8.8 Lubricant shall be selected for prolonged storage and use of the motor in a tropical climate and shall contain corrosion and oxidation inhibitors and anti foaming agents. Grease shall have suitable bleeding characteristics to minimize setting. Data regarding suggested re greasing intervals shall be furnished in the offer. In case of reactor building motors, which are required to operate following Loss of Coolant Accident (LOCA) and Main Steam Line Break (MSLB), bearing lubricant and bearing shall be capable of remaining in satisfactory operating condition after withstanding pressure and temperature conditions prevailing at the motor location during and subsequent to LOCA and MSLB.

5.8.9 When pressure lubrication is required or recommended as for large motors, motor bearings shall be of the sleeve type arranged for pressure lubrication, supplied from lubrication system of the driven machine, with ring oiling for starting and emergency duty. The ring oiling shall be adequate for starting and continuous operation of the motor for at least 5 minutes without the pressure oiling system in operation. Oil sight flow gauges shall be supplied to indicate oil flow from each motor bearing.

5.8.10 In respect of forced lubrication, an oil flow indicator to each bearing together with necessary oil tank complete with clearly visible oil level indicator to show oil level at running and standstill, oil cooler, filter, piping, valves, pressure switches for low oil alarm, pressure gauges, and stand by motor-driven pump to start automatically in the event of failure of the main pump etc., to complete the system shall be supplied. Adequate lubrication shall be ensured during all conditions such as starting, running and coasting down. Motor manufacturer should provide details regarding the lubrication system and scope of supply such as piping etc.

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5.8.11 When the motor shaft is not located axially by its own bearing, it shall be permanently marked to indicate its running position and the extent of float in either direction.

5.9 **Heat Exchangers**:

5.9.1 Adequate margin shall be provided in the design of heat exchangers to allow for fouling of cooling tubes or ducts under service conditions. Provision shall be made for easy cleaning of tubes or ducts where possible on load.

5.9.1.1 Air-cooled Heat Exchangers: The cooling tubes or ducts shall be adequately braced and supported to prevent vibration and premature fatigue or fracture. The design shall provide an effective seal between the primary and secondary air circuits and it shall be possible to carry out maintenance without damage to this seal. For motor above 1000 kW, a dial type thermometer with alarm and trip contacts shall be provided to give warning in case of excessive air in let temperature.

5.9.1.2 Water-cooled Heat Exchangers: The heat exchangers and any connecting piping shall be arranged to eliminate any possibility of water entering the motor enclosure and falling on the motor winding, etc. in the event of a leakage of cooling water. Heat exchangers shall be provided with valves for draining from its lowest points. Cooling system shall be complete with heat exchangers, piping, valves, instruments etc to make the system complete. Details shall be submitted along with the offer. The materials for the cooler shall be such as to avoid any electrolytic action. Water coolers shall be hydro tested with water as a test medium at 1.5 times the maximum working pressure. A dial type thermometer with alarm and trip contacts shall be provided to give warning of excessive motor in-let air temperature. Heat exchangers for Motors provided with air to air or air to water heat exchangers shall be designed, manufactured, inspected in accordance with applicable national standards for such heat exchangers. In case of air to water heat exchangers, water leak detection switches along with flow switch with water flow indicators shall be provided. The design of heat exchanger shall take in to account the maximum air temperature and or the maximum water temperature from Purchaser's sources, allowable pressure drop, maximum temperature of outlet water etc. The permissible temperature rise of motor winding shall be calculated considering the maximum temperature for the winding specified and temperature of cold air leaving the heat exchanger under the worst conditions of ambient air/ water. The design of heat exchanger shall be subject to approval of the Purchaser

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5.10 **Balancing and Vibration**:

5.10.1 Bidder shall submit detailed procedure and technical parameters with regard to balancing and vibration in the technical offer.

5.10.2 Vibrations in all the three directions for horizontal motors shall be within the limits specified in IEC-60034. For vertical motors the values shall not exceed the same limits for lower bearings and 1.5 times these limits for upper bearings. Tests for measuring amplitudes and velocity of vibration on all directions shall be carried out in the presence of Purchaser's representatives on all motors. Test data with test diagram showing amplitudes and velocity of vibration at various locations shall be submitted along with test reports.

5.10.3 Balancing of rotor with all components mounted shall be carried out at rated RPM or as permitted by the standards. Facility should be provided for trim balancing of motor at site. A chart indicating the details of balancing weights added and their locations shall be enclosed as a part of test reports. Balancing shall be to grade Gr 2.5 according to ISO 1940. Report shall be a part of Routine test reports.

5.10.4 Components such as flywheel, fan, coupling etc., that are to be mounted on the shaft shall be individually balanced to enable future replacements.

5.10.5 Weights added for the purpose of balancing shall be free of defects and shall be firmly fixed such that there is no displacement while in service.

5.10.6 Vibration monitoring facility if asked in annexure-A shall be provided for each motor of that type.

5.11 **Grounding**:

5.11.1 For all motors, a non-corrodible terminals shall be provided at two locations on the motor frame and each shall have a threaded hole of M12 size and shall be provided with suitable bolts, nuts, washers and spring washers. The threaded hole shall be of sufficient depth to ensure adequate electrical contact between external connector and motor frame. Separate earthing terminals of M12 size (or of appropriate size concurred by the Purchaser) shall be provided for the power terminal box.

5.11.2 Gasketted joints shall be provided with metallic bypass connections of adequate size to ensure earth continuity.

5.12 **Space Heaters**:

5.12.1 Motors shall be provided with space heaters of adequate capacity to maintain motor internal temperature above the dew point to prevent moisture condensation when the motor is not in service. The heaters shall be mounted inside the motor in accessible place so that their removal and replacement is a simple operation. Space heaters shall be rated for 240 volts, single phase, 50 cycles and shall be located in lower part of motor.

5.13 **Couplings**:

5.13.1 Driven equipment manufacturer shall work out details of coupling arrangement. Motor manufacturer shall provide necessary information to the driven equipment supplier and meet the requirements of the driven equipment manufacturer.

5.14 **Direction of Rotation**:

5.14.1 Direction of rotation shall be as required by the driven equipment and the same shall be indicated in drawings, documents and motor frame.

5.14.2 Where specified, a mechanical device to prevent reverse rotation shall be provided. The rating of mechanical reverse rotation stop shall be such that it can prevent reverse rotation when the torque in the reverse direction is not greater than 100% of rated torque of the motor in the forward direction.

5.15 **Mounting and Dowelling**:

5.15.1 Mounting arrangement shall be matched with the requirements of the driven equipment.

5.16 **Lifting facility**:

5.16.1 Motors shall be provided with adequately designed eyebolts, lugs or other devices to facilitate safe lifting operations.

5.17 **Drain Plugs**:

5.17.1 Motors shall have drain plugs to permit removal of water accumulated inside the motor.

5.18 **Base Frames**:

5.18.1 When a motor is supplied with driven equipment having common base frame, the supplier of the driven equipment shall determine that such base frame is adequately braced to keep vibration and misalignment within permissible limits. Driven equipment supplier shall be responsible for supply of all required mounting arrangements considering the motor and driven equipment assembly.

5.19 **Name plate and Diagram of Connections**:

5.19.1 Motor shall have a nameplate showing all the particulars specified in relevant clause of IS-60034. In addition, the nameplate shall also indicate

(a) The type of bearings used for motor, the details of recommended lubricant and re-lubrication interval
(b) Limit and conditions of successive starts. Separate name plate shall be provided for forced lubrication & heat exchanger system.
(c) Frame reference, insulation class, efficiency, winding connection
(d) Rotor secondary voltage and current (at rated output) for wound rotors

6.0 PERFORMANCE REQUIREMENTS

6.1 **Starting Duty**:

6.1.1 Motors shall be capable of two successive restarts coupled to its driven equipment with coasting to rest between starts under both cold and hot conditions and a third restart shall be feasible after 20 minutes. The motor shall further be capable of three equally time spaced starts per hour under normal service conditions.

6.1.2 Motors shall be designed for direct on line, full voltage starting and shall withstand all stresses and give satisfactory performance when started with their driven equipment connected under all operating conditions specified for the driven equipment. The end windings of stator and rotor shall be adequately braced and supported to cater to the different starting duty conditions, bus transfer etc. The total number of starts during the design life of motor shall be commensurate with the requirements of driven equipment.

6.1.3 Motor shall be capable to starting and accelerating the driven equipment satisfactorily at a minimum voltage of 80% of the nominal voltage at the motor terminals.

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6.2 **Locked Rotor current for squirrel cage rotor**.

6.2.1 Unless otherwise specified in Annexure-A, the locked rotor current shall not exceed six times the rated current including IS tolerances.

6.3 **Fast Bus Transfer**:

6.3.1 Motors shall be capable of withstanding the torque stresses and forces developed due to the vector difference between the motor residual voltage and the incoming supply voltage during fast changeover of the supply. The complete drive train assembly and motor winding shall be adequately designed to withstand mechanical forces developed during such conditions. Vendors shall carry out torsional analysis after obtaining NPCIL system data and submit analysis report.

6.4 **Pull out:**

6.4.1 Motor shall not pull out of step when the supply voltage drops to 70% of the rated motor voltage for a short duration of 25 cycles during full load operation of motor. To meet this requirement, the pull out torque of the motor at rated voltage shall be at least 200% of full load torque.

6.5 **Over speed**:

6.5.1 Unless otherwise indicated in annexure-A, motors shall be capable of withstanding without mechanical damage, at least 120% of rated speed or as imposed by the driven equipment, whichever is higher.

6.6 **Other requirements**:

6.6.1 Motors shall be capable of satisfactory operation at full load without injurious heating when the motor terminal voltage is at 80% of rated voltage for ten minutes.

6.6.2 In all cases involving typical centrifugal pumps, compressors etc. acceleration time of motor at 80% terminal voltage shall not be greater than the locked rotor withstand time under hot condition at 100% voltage. The safe stall time of the motor shall be such that taking in to account the accelerating time of the motor with the driven equipment and specified number of hot and cold starts, adequate margin exists and the motor remains safe. Where such a condition cannot be satisfied due to high inertia of the motor and driven equipment assembly and if specially approved by the Purchaser before placement of order, suitable speed switch with two potential free contacts and

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speed sensing and monitoring system for remote speed monitoring shall be provided along with the motor. Details of such speed sensing and monitoring system shall be included in the offer. After placement of order, motor manufacturer shall submit calculations indicating the safe stall times and permitted number of cold and hot re-starts considering permissible stator and rotor temperature under stall conditions. The permissible stator and rotor temperatures for the purpose of calculating safe stall times shall be limited to 185^0 C and 400^0 C for stator with class-F insulated copper conductor and rotor copper bars respectively.

6.6.3 If specified in Annexure-A, driven equipment vendor by analysis of complete assembly of motor, coupling, driven equipment and mounting arrangements shall qualify that motor and the driven equipment assembly would continue to perform intended function during and after subjected to specified level of earthquake without any deterioration in the performance.

6.6.4 Motors offered shall have high efficiency values with tolerance as per IEC-60034.

7.0 SPARE PARTS

The supplier shall recommend spares that are required for 5 years operation and required to be stocked for maintenance purpose. However, as a minimum, supplier shall furnish prices for the following in his tender.

i) One set of complete bearing assembly for drive and non-drive ends.
ii) One complete motor spare of each type and rating.
iii) One set of space heaters.
iv) Wherever provided, one speed sensor, speed processing equipment along with alarm and trip contacts (if not covered in C&I spare clause for particular motor type and rating).
v) Seals, gaskets, O' rings and other materials which require periodic replacement.
vi) Winding/Bearing RTDs, one of each type (if not covered in C&I spare clause for particular motor type and rating).
vii) Shaft insulating sleeve (to prevent shaft current) wherever applicable
viii) One set of CTs (3 nos.) for differential protection if provided.
ix) Six number of terminal bushings

Spares to be supplied should be physically and technically interchangeable with similar components already installed/in use and shall undergo all inspections and tests as per the QAP approved for the motors ordered.

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8.0 INSPECTION AND TESTS:

8.1 Vendor shall submit detailed test plan and procedure as per this Specification and latest applicable IS/IEC or other standards for NPCIL concurrence.

8.2 All routine tests mentioned in Annexure-C shall be conducted **on all motors** by the manufacturer at his work and test certificates shall be furnished to the Purchaser's representative (QA) for approval. The cost for the same shall be included in the equipment prices and no extra charges are payable.

8.3 On one typical motor of each design, test reports for all type tests as given in Annexure-C shall be submitted for purchaser's review. In case type test reports are not acceptable to the Purchaser, type tests shall be performed at no extra cost to the Purchaser and without affecting the delivery period. Type test certificates shall be submitted for review and approval of the Purchaser. Type test reports shall not be earlier than 5 years from date of purchase order. Any special test and or qualification test if specified in Annexure-A shall be performed in accordance with an approved procedure and test reports shall be submitted after testing / qualification. The cost of type tests (as given in Annexure-C) on one motor shall also be included in the prices of the equipment quoted and no extra price is payable. Cost for special tests (as indicated at Annexure-A) shall be indicated separately and are payable if tests are performed and results are accepted.

8.4 For existing type test report submitted by vendor, tested motor shall have similarity in design and dimension, construction, gasket sealing material & arrangement with the motors to be supplied. In the absence of the above, Purchaser can ask to repeat the type test at no extra cost to Purchaser.

8.5 The supplier shall be responsible and shall provide for and perform all the necessary tests, compile reports, documents, arrange inspection and testing to ensure that the material, equipment and workmanship are in accordance with the stipulation detailed in the QAP attached with this specification. All inspection and test reports and reports reviewed shall form part of end documentation.

8.6 The Purchaser or his authorised representative shall at all reasonable times have access to those parts of the supplier's or sub-supplier's works concerned with the manufacture of the motor for the purpose of witnessing tests and ascertaining compliance with the requirements of this specification. The Purchaser shall also have the right to conduct at his expense any additional tests or inspection he deems necessary.

8.7 Supplier shall furnish material specification test certificates as required in the QAP and shall be in a position to co-relate these certificates with the actual material used for the motors.

8.8 After receipt of the Purchase order, the supplier shall furnish to the Purchaser a detailed schedule of manufacture and delivery to enable Purchaser's inspector to plan visits to the manufacturer's works for inspection during different stages of manufacture, which shall be as per detailed quality control plan attached as Annexure 'C'. The supplier will be required to develop a quality control plan in line with the requirements indicated in Annexure 'C' and submit the QAP for approval by Purchaser.

8.9 The contractor shall supply to Purchaser's representative a complete set of detailed fabrication drawings which will be used in the inspection during manufacture, which will be retained at the factory and returned after completion of the contract.

8.10 All repairs and rework shall be informed to the Purchaser and his approval taken before proceeding further. All such repair work shall be documented and where desired by the Purchaser, photographic records shall be maintained. These documents shall be included in end documents.

8.11 Ultrasonic, dye penetrant and radiographic examination shall be conducted as per approved NPCIL procedure which shall be submitted to the successful bidder.

9.0 PAINTING AND PACKING:

9.1 The motor external parts shall be finished and painted to produce a neat and durable surface, which would prevent rusting, and corrosion. The equipment shall be thoroughly degreased, all rust, sharp edges and scale removed. The painting system shall be epoxy based having Polyamide cured non-inhibitive epoxy paint compatible with inorganic ethyl zinc silicate primer with epoxy topcoats to shade 631 of IS-5.

9.2 All materials/ spares that have limited shelf life shall be marked in bold to indicate their storage conditions and expiry date.

9.3 The motor shall be packed for dispatch to project site in strong wooden crates. The following information shall be clearly given on each box.

a) Purchaser

b) Purchaser order number

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c) Equipment code number, if any.

d) List of contents of each package

e) Storage instructions

9.4 The packing should incorporate measures to prevent damage to motor winding, bearing and shaft due to jerks and shocks during transit. The packing should afford reasonable protection against ingress of rainwater.

10.0 DRAWINGS AND DOCUMENTS:

10.1 Supplier shall furnish following drawings for Purchaser's approval within 4 weeks of placement of purchase order:

a) Drawings showing overall dimensions and all other essential dimensions along with cross-sectional views and motor data sheets as per Annexure-B.

b) Detailed drawing for terminal boxes, clearance, conductor termination, cable gland and degree of protection should also be marked on this drawing. Details of conductor from terminals to the stator winding shall be indicated.

c) Drawing showing conductor details in slots, thickness & materials of insulation and conductor cross section and detailed write up on the insulation system provided for the motor winding.

d) Dimensioned drawings of bearings with cross-sectional views.

e) Flow sheets for cooling, lubrication and other auxiliary systems, if provided.

f) Drawing showing locations of winding RTDs and BTDs. RTDs should be identified with the windings they are associated with.

g) All details submitted to the driven equipment supplier for the purpose of seismic qualification of the driven equipment and the motor assembly, application check for the motor to confirm suitability of the motor to the requirements of driven equipment.

h) Welding/Brazing procedures and acceptance norms.

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i) Ability of the drive train to withstand torsional stresses due to fast transfer.

j) Handling, assembly and disassembly details.

k) Site preservation instruction details

l) Material and dimension details of all types of gaskets and O' rings used in motor.

m) Detailed procedure for assembly and disassembly of motor of each type and rating.

10.2 Supplier shall take up manufacturing after the Purchaser has approved the drawings.

10.3 3 prints of all drawings should be submitted for approval. After execution of the order, three sets of hard copies of all documentation and two sets of CDs with all scanned copies of documents, drawings, data sheets and characteristic curves, all routine, type tests and documents related to stage wise inspection shall be supplied.

10.4 Following characteristic curves/drawings shall be supplied:

10.4.1 Torque Vs speed curves for the motor superimposed with load torque vs speed characteristics.

10.4.2 Starting current Vs time and speed at 100% and 90% and 80% voltages.

10.4.3 Power factor, efficiency, load current Vs Load

10.4.4 Thermal withstand characteristics for motor under cold and Hot conditions

10.4.5 Negative sequence current capability curve

10.4.6 Residual voltage Vs time (With and without pump)

10.4.7 Winding diagram

10.4.8 Motor equivalent circuit diagram showing stator and rotor resistance, leakage reactance and magnetizing reactance

10.4.9 Efficiency and Power factor vs. speed

10.5 Motor manufacturer shall also submit the recommended relay settings for specified pump load.

11.0 INSTRUCTION MANUALS

11.1 Supplier shall furnish 3 copies of instruction manuals and two CDs with completely scanned copies of documents covering storage, installation, detailed assembly, disassembly procedures, operation and maintenance of the motors, site preservation instructions. Installation instructions shall include procedure for checking alignment of motor shaft, coupling and base. Instruction shall also cover lubricating details including recommended inspection and replacement schedules, quantity of lubricant required and specifications for the lubricant and its equivalent. Instruction manual shall include one set of all approved drawings, a complete part list, descriptive literature for all components such as Heat exchangers, RTDs, fans, filters, space heaters etc and complete details of motor in Annexure –‘ B’ as per requirement.

11.2 In addition, three copies of the above instruction manual shall be supplied with each motor.

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Motor Tag Nos:
Quantity:
Project Title:

	Process Group	Electrical Design Group
Prepared by		
Reviewed by		
Approved by		

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Sl. No.	Particulars	
1.0	**OPERATING CONDITIONS**	
1.1	Ambient temperature	50°C
1.2	Altitude	Less than 1000M
1.3	Humidity	
1.4	Type of environment (corrosive/non-corrosive)	Non-corrosive
1.5	Location (indoors/outdoors)	
1.6	Hazardous condition	
1.7	Rated voltage and its variation	6.6kV±10%
1.8	Rated frequency and its variation	50Hz±5%
1.9	Permissible un-balance in supply voltage	3%
1.10	Permissible harmonic content in supply voltage	5%
1.11	Combined voltage & frequency variation	10% (absolute)
1.12	Number of phases	3
1.13	Method of system grounding	Resistance grounded
2.0	**GENERAL**	
2.1	Application/Driven equipment	
2.2	Type of motor (SCR/SR)	SCR
2.3	Nature of application of the motor	Motor is safety related / Motor is not safety related but critical / General Purpose.
2.4	Reverse rotation stop required	Yes/No
2.5	Type of reverse rotation stop	Mechanical ratchet type/Electronic type
2.6	Applicable standards/codes	IEC-60034, IS-14578, PC-E-503
2.7	Stator winding connection	Star
3.0	**RATING**	Driven equipment vendor to select the rating considering all operating conditions and provide a margin of 10%
4.0	**DUTY**	
4.1	Type of duty	S1, Continuous
4.2	Over speed operation requirements	
5.0	**STARTING**	
5.1	Method of starting	Direct On Line (DOL)
5.2	Permissible starting current as % of full load current at rated voltage	
5.3	Minimum voltage required for starting & accelerating at full load	80% of rated voltage

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5.4	Number of successive starts on full load followed by next start after 20 minutes. (a) In cold condition (b) In hot condition.	 Minimum 2 Minimum 2
5.5	No. of equally spread starts per hour.	Minimum 3
6.0	**INSULATION**	
6.1	Class of insulation for stator winding	Minimum Class-F
6.2	Permissible temperature rise: a) Under normal conditions b) Under extreme voltage conditions (90% of rated voltage):	 a) 70˚C (ambient temp.-50˚C) b) 80˚C (ambient temp.-50˚C)
6.3	Main insulation impulse withstand voltage	31.4kVp
6.4	Inter turn impulse withstand voltage	20.4kVp
7.0	**CONSTRUCTION & MATERIALS**	
7.1	Degree of protection	
7.2	Type of enclosure	
7.3	Material for rotor bars	Copper
8.0	**TERMINAL BOXES**	
8.1	Type of main HT stator terminal box	Phase segregated
8.2	Neutral T. Box suitable to accommodate differential C.T.	Required / Not Required
8.3	Degree of protection for TB enclosure	IP55
8.4	Number of cable entries.	
8.5	Power cable size and type.	
8.6	Separate terminal box required for: Stator phase terminals For forming star connections Space heater terminals Winding RTD's terminals Bearing ETD's terminals	 Yes/No Yes/No Yes/No Yes/No Yes/No
8.7	Size of cable for space heater external connection	2.5/4/6 sq.mm Cu. conductor, 2 core PVC cable.
8.8	Size of cable for RTD and BTD external connection.	
9.0	**BEARINGS**	
9.1	Type of bearings	
9.2	Type of lubrication	
9.3	Expected re-lubrication interval	
9.4	Bearing cooling	
9.5	Whether bearings are required to operate during and after LOCA/MSLB	
9.6	Whether any additional accessories are required	

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	for bearing cooling system, if so indicate		
10.0	**ACCESSORIES**		
10.1	Temperature detector in windings: a) For PCP b) For all other motors		a) PT-100, 2 wire simplex b) PT-100, 5 wire simplex
10.2	Temperature detector in bearings: a) For PCP b) For all other motors		c) PT-100, 2 wire simplex d) PT-100, 4 wire duplex
10.3	Whether dial type temperature indicator required for following: a) Bearings b) Cooling air/water		a) Yes/No b) Yes/No
10.4	Whether CTs for differential protection required		Yes/No
10.5	Inspection plugs for air gap measurement required?		Yes/No
10.6	RTD insulation class		Class H
10.7	Vibration monitoring system required?		Yes/No
11.0	**COOLING**		
11.1	Type of cooling		
11.2	Quality of cooling water (if other than IS: 1710)		
11.3	Cooling water pressure at inlet		
11.4	Leakage detector required		Yes/No
11.5	Maximum temperature rise of cooling water and permissible pressure differential across the heat exchanger		
11.6	Any additional instrumentation requirements associated with forced water-cooling? Indicate details.		
12.0	**INSPECTION**		
12.1	Inspection as detailed in the specification and typical QAP attached as Annexure-C required?		Yes/No
12.2	Acceptance criteria for NDT as per applicable standards as follows:		
	i)	Liquid penetrant inspection	As per Annexure-E
	ii)	Ultrasonic inspection	As per annexure-D
12.3	Whether any special tests other than those indicated in this specifications and Indian Standards are required to be performed? If so, indicate details.		
12.4	Whether seismic qualification of complete motor		

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	and driven equipment assembly along with all accessories and auxiliaries are required to be qualified for the specified seismic levels at its location?	<table><tr><td>Seismic level</td><td>Structural integrity</td><td>Operability</td></tr><tr><td>SSE</td><td></td><td></td></tr><tr><td>OBE</td><td></td><td></td></tr></table>
13.0	**Special Requirements for Reactor building motors**	
13.1.	Whether the complete motor assembly is required to be qualified for operation during and following LOCA/MSLB?	Yes/No*
13.2	If motor is required to be qualified for LOCA/MSLB, enclose applicable temperature and pressure transient details.	
13.3	Tag number of motor required to be qualified for LOCA/MSLB	
13.4	Whether motor insulating materials, auxiliaries, wiring, terminal blocks, connectors, gaskets, lubricants etc are required to withstand radiation and operate satisfactorily?	Yes/No 1) For normal conditions only. 2) For normal and accident conditions.
13.5	Cumulative radiation dose under normal and accident conditions.	
13.6	Cumulative radiation dose under normal conditions	
13.7	Tag number of motor for which radiation qualification is required but LOCA/MSLB qualification is not required.	
13.8	Expected external over pressure likely to be experienced by motors and their accessories during reactor building pressure test.	
14.0	Specific Requirements if any pertaining to shaft, fly wheel, bearing, brake / anti reverse rotation device and analysis etc.	1. 2. 3. 4. 5.

* Detailed procedure shall be worked out by the Contractor and subjected to review and approval of Purchaser.

NUCLEAR POWER CORPORATION OF INDIA LIMITED	
ANNEXURE-B to PC-E-503 **FORMAT FOR SUBMISSION OF TECHNICAL PARTICULARS FOR HIGH VOLTAGE INDUCTION MOTORS** **(To be filled in by Motor Manufacturer and submitted by driven equipment Manufacturer or Package Contractor alongwith quotation and after finalisation of motor design and engineering)**	**Project :700MWe** **Page : 1 of 11**

.

Cover Sheet for Motor Data Sheets

1.	Name and address of Motor Manufacturer		:	
2.	Name and address of driven equipment manufacturer		:	
3.	Name and address of Package contractor		:	
4.	References		:	
	i)	NPCIL's Purchaser Order No.	:	
	ii)	Package Contractor's Purchase Order No.	:	
	iii)	Driven Equipment Supplier's Purchase Order No	:	
	iv)	Work Order Number of Motor Manufacturer	:	
5.	Document No.		:	
6.	Rev. No. & Date		:	
7.	Motor Tag Nos.		:	
8.	Quantity		:	
9.	Project Title		:	
10.	Contents		:	
	i)	Motor data sheets	:	Sheet 1 to 10
	ii)	Motor & load Torque vs Speed Curves	:	Sheet 11
	iii)	Performance Curves	:	Sheet 12
	iv)	Current and speed vs starting time	:	Sheet 13
	v)	Thermal withstand characteristics	:	Sheet 14
	vi)	Negative sequence current withstand capability curve	:	Sheet 15
	vii)	Residual voltage v/s time characteristics	:	Sheet 16
	viii)	Write up on insulation system	:	Sheet 17

	Motor Manufacturer	Driven Equipment Supplier	Package Contractor
Prepared by			
Reviewed by			
Approved by			

Motor manufacturer's name and address	**Date of issue, Rev No**

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Sl.No.	Particulars		
1.0	**Guaranteed operating conditions for the motor(s)**		
1.1	Ambient temperature ^{0}C		
1.2	Cooling water temperature at inlet ^{0}C.		
1.3	Altitude		
1.4	Humidity (%)		
1.5	Type of environment (corrosive/non-corrosive)		
1.6	Location (indoors/outdoors)		
1.7	Hazardous condition.		
1.8	Rated voltage & its variations.		
1.9	Rated frequency & its variations.		
1.10	Permissible un-balance in supply voltage		
1.11	Permissible harmonic content in supply voltage		
1.12	Combined voltage & frequency variations		
1.13	Number of phases		
1.14	Method of system grounding.		
1.15	Seismic capability: if specified in the annexure-A, whether qualification of motor and the driven equipment assembly along with accessories and auxiliaries included in the scope of the tender? Indicate the proposed method of qualification.		
1.16	Auxiliary power supply requirements		
	i)	For auxiliaries	
	ii)	For space heaters	
	iii)	For instrumentation & control	
2.0	**GENERAL**		
2.1	Application/Driven equipment		
2.2	Method and type of coupling to driven equipment.		
2.3	Type of motor (SCR/SR)		
2.4	Frame size		
2.5	Mounting		
2.6	Single shaft / double shaft extension.		
2.7	Direction of rotation (viewed from drive end)		
2.8	Rotation – uni /bi-directional		
2.9	Reverse rotation stop provided?		
2.10	Applicable standards/codes.		
2.11	Stator winding connection		
2.12	Winding resistance per phase*		

Motor manufacturer's name and address	**Date of issue, Rev No**

NUCLEAR POWER CORPORATION OF INDIA LIMITED	
ANNEXURE-B to PC-E-503 **FORMAT FOR SUBMISSION OF TECHNICAL PARTICULARS FOR HIGH VOLTAGE INDUCTION MOTORS** **(To be filled in by Motor Manufacturer and submitted by driven equipment Manufacturer or Package Contractor alongwith quotation and after finalisation of motor design and engineering)**	**Project :700MWe** **Page : 3 of 11**

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Sl.No.	Particulars		
3.0	**RATING**		
3.1	Rated output (KW)		
3.2	Rated speed (RPM)/Synchronous speed (RPM)		
3.3	KW actually required by the drive equipment under specified operating conditions.		
4.0	**DUTY**		
4.1	Type of duty		
5.0	**STARTING**		
5.1	Method of starting		
5.2	Starting current (% of full load current)		
5.2.1	At rated voltage		
	a)	With I.S. tolerance	
	b)	Without I.S. tolerance	
5.2.2	At 80% voltage		
	a)	With I.S. tolerance*****	
	b)	Without I.S. tolerance*****	
5.3	Minimum voltage required for starting		
5.4	Starting time with DOL starting with driven equipment coupled		
	a)	At rated voltage	
	b)	At 80% voltage *****	
	c)	At 110% voltage *	
5.5	Permissible No. of successive starts on full load.		
5.5.1	In cold condition		
5.5.2	In hot condition.		
5.6	No. of equally spread starts per hour.		
6.0	**INSULATION**		
6.1	Class of insulation for stator		
6.2	Permissible temperature rise (by resistance method)		
	a)	Under normal conditions:	
	b)	Under extreme voltage conditions (90% of rated voltage):	
6.3	Tropical Treatment of motor		
6.3.1	Material of insulation (Please enclose complete write up in a document form showing sectional view of slot, over hang and detailing the insulation system)		
6.3.2	Treatment of insulation, stator and rotor core for anti-fungal growth		
6.4	Main insulation impulse withstand voltage		

Motor manufacturer's name and address	**Date of issue, Rev No**

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Sl.No.	Particulars		
6.5	Inter turn impulse with stand voltage		
6.6	Radiation withstand capability of insulation system and other materials used in the motor (If specified, only for motors located in the reactor building)		
7.0	**COSTRUCTION & MATERIALS.**		
7.1	Degree of protection provided by the enclosure		
7.2	Enclosure type (Fabricated type/ casting)		
7.3	Enclosure material grade for		
	a)	Frame	
	b)	End shields	
	c)	Power terminal box	
	d)	Bearing housing	
	e)	Gaskets	
7.4	Material for stator conductors		
7.5	Material for rotor bars		
7.6	Material for short circuiting rings*		
7.7	Material for retaining rings*		
7.8	Material for rotor shaft		
7.9	Material for fly wheel (if provided)		
7.10	Heat loss to environment for the purpose of ventilation design *		
7.11	Type of cooling		
7.12	Painting		
7.12.1	Primer: - (Compatible with epoxy paint and based on inorganic ethyl zinc silicate?)		Yes/ No If No, indicate details
7.12.2	Finish Coats:- (Epoxy?)		Yes/ No. If no, indicate details
8.0	**TERMINAL BOXES**		
8.1	Type of main HT stator T. Box		Phase segregated
8.2	Fault withstand capacity at rated voltage and its duration for:		
	a)	Internal faults	
	b)	External faults, kA (rms & peak)	
8.3	Neutral T. Box suitable to accommodate differential C.T.		
8.4	Size of T. Box (inside dimensions)		
8.5	Degree of protection for T. Box enclosure.		
8.6	No. of cable entries.		
8.7	Max. cable size suitable for the terminal box/Actual size		
8.8	No. of terminals for main winding. *		

Motor manufacturer's name and address	**Date of issue, Rev No**

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Sl.No.	Particulars		
8.9	Size of connections from windings to terminals. ***,** (Min. 110 sqmm, Cu)		
8.10	Details of type test certificates to prove the capability of motor power terminal box to prove its capability to meet requirements stated in this specification.		
8.11	Separate terminal box provided for:		
	a)	Stator phase terminals (Yes/No)	
	b)	Rotor phase terminals (Yes/No)	
	c)	For forming star connections (Yes/No)	
	e)	Space heater terminals (Yes/No)	
	f)	Winding RTD's terminals (Yes/No)	
	g)	Bearing ETD's terminals (Yes/No)	
	h)	Whether provision of flexible metallic conduits as specified in clause no 5.17.15 included in scope of supply?	
8.12	Direction of cable entry.		
8.13	Size of cable gland plate suitable for		
	a)	Motor cable*	
	b)	Space heater cable*	
	c)	RTD cable*	
8.15	Whether disconnecting type terminals for CTs provided?		
8.16	Plug-in terminals for RTDs, accessories, BTDs etc provided for motors?		
9	**BEARINGS**		
9.1	Type of bearing		
9.2	D.E bearing number and make.		
9.3	N.D end bearing number and make		
9.4	Standard L10 life of bearing.		
9.5	Type and grade of lubricant*		
9.6	Quantity of lubricant required*.		
9.7	Bearing cooling.		
9.8	Bearing insulation for shaft current provided (Yes/No)		
9.9	Bearing end play (mm)* Axial Radial		
9.10	Thrust bearing losses*		
9.11	Regressing interval.		
9.12	Maximum permissible bearing temperature DE		

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Sl.No.	Particulars		
	NDE		
9.13	Whether bearings are designed considering all loads expected during all operating conditions including seismic conditions (if specified) of the driven equipment?		
9.14	Whether bearings are designed for operation during and after LOCA/MSLB, (only if the requirement is specified)		
9.15	List of auxiliaries and instruments provided incase of forced cooled bearing		
9.16	Detailed write up on bearing forced cooling enclosed?		
10	**ACCESSORIES**		
10.1	Temperature detectors in windings		
10.2	Temperature detectors in bearings		
10.3	Space – heaters		
	a)	Voltage	
	b)	Wattage/ space heater	
	c)	Nos. proposed to be used	
	d)	Location	
	e)	Expected temperature of in side air above the out side ambient air temperature	
10.4	Dial type temperature indicator for the following provided		
	a)	bearings	
	b)	cooling air/water	
10.5	CTs for differential protection provided? if yes; indicate details of CTs.		
10.6	Inspection plugs for air-gap measurement provided?		
10.7	RTDs insulation details		
10.8	Whether RTDs leads are screened		
11	**Heat Exchangers (if provided)***		
11.1	Medium in the shell side*		
11.2	Medium in the tube side*		
11.3	Heat exchanged*		
11.4	Quantity of fluid in the tube side*		
11.5	Quantity of fluid in the shell side*		
11.6	In let and out let temperatures of fluid in the tube side*		
11.7	Inlet and out let temperatures of fluid in the shell side*		
11.8	Material of the tubes*		
11.9	Material of the shell/enclosure*		
11.10	Number and diameter of tubes*		
11.11	Design pressure of water system		

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Sl.No.	Particulars		
11.12	Design pressure of air system		
11.13	Maximum permissible inlet pressure for Purchaser's water to HX		
11.14	Water leak detector provided?		
11.15	Maximum temperature of cool air entering motor under maximum temperature of inlet water.		
11.16	Maximum differential pressure across the HX for purchaser's process water.		
11.17	Design and manufacturing standards		
12	**WEIGHT AND MOMENT OF INERTIA**		
12.1	Weight of stator (Kg.)*		
12.2	Weight of rotor (Kg.)*		
12.3	Total weight of motor (Kg.)		
12.4	Shipping weight of motor (Kg.)*		
12.5	Shipping dimensions LXBXH*		
12.6	Rotor GD^2 (kgm^2)*		
12.7	GD^2 of driven equipment referred to motor speed (kgm^2)*		
13	**PERFORMANCE**		
13.1	Full load current (amps)		
13.2	No load current. (amps)		
13.3	Full load speed (rpm)		
13.4	No load speed (rpm)		
13.5	Efficiency At full load (%) At 75% load (%)* At 50% load (%)*		
13.6	Power factor At full load At 75% load* At 50% load*		
13.7	Noise pressure level of motor at 1.0 m at no load db (A)		
13.8	Velocity of vibration at		
	a)	No load (microns), mm/s	
	b)	With load (microns), mm/s	
13.9	Critical speed (rpm)		
	a)	Upper*	
	b)	Lower	
13.10	Safe stall time secs at 80% & 100% voltages		
	i)	When motor is at rated operating temperature	
	ii)	When motor is at ambient temp.	

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Sl.No.	Particulars		
	iii)	Limiting stator and rotor temp. considered to determine stall time – Deg.C	
13.11	The minimum number of starts the motor is capable of during its lifetime of 40 years?		
13.12	a)	Stator heating time constant.	
	b)	Stator cooling time constant	
13.13	Overload capacity:		
13.14	Torque		
13.14.1	Torque at full load.		
13.14.2	Starting torque (% if full load torque) At rated voltage At 80% voltage		
13.14.3	Pull-out torque (% of full load torque) at rated voltage		
13.14.4	Pull-up torque (% of full load torque) at rated voltage		
14.0	**CONNECTIONS**		
14.1	Stator		
14.2	Number of connections brought out.		
14.3	Cross section of connections from winding to terminals		
15.0	**INSPECTION**		
15.1	Purchaser's inspection in works as specified detailed in QAP agreed?		Yes/No
15.2	NDT as per applicable Annexures will be done as follows on shafts, welds etc:		
	i)	Liquid penetrant inspection	Yes/No
	ii)	Ultrasonic inspection	Yes/No
15.3	Welding procedure and welder qualification as specified agreed?		Yes/No
15.4	Brazing procedure qualification and brazer qualification agreed for brazing of stator connections and rotor bars with end rings?		Yes/No
15.5	Performance of all routine tests as specified agreed?		Yes/No
15.6	Performance of all type tests as specified agreed?		Yes/No
15.7	Whether full compliance to QAP attached as Annexure-C to PC-E-503 agreed?		Yes/No
15.8	Whether full compliance to PC-E-503 and annexure-A, Annexure-D and Annexure-E to PC-E-503 agreed?		Yes/No. If no, clearly indicate clause wise deviations
16.0	**DRAWINGS, CATALOGUES, DATA SHEETS**		

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Sl.No.	Particulars		
16.1	Descriptive pamphlets for the offered motor enclosed?		Yes/No
16.2	Details of reverse rotation stop enclosed?*		
16.3	Torque vs. speed characteristics curve at rated voltage and frequency		
	a)	For motor	
	b)	For driven equipment	
16.4	Current vs. speed characteristic curve at rated voltage and frequency during acceleration*.		
16.5	Thermal withstand characteristic curves and data in digital form for		
	a)	Hot condition*	
	b)	Cold condition*	
16.6	Current vs. time characteristic curve during acceleration*		
16.7	Negative sequence current capability curve*		
16.8	Efficiency. Power factor, speed and current vs. load characteristics*		
16.9	Efficiency, Power factor vs. speed characteristics*		
16.10	Dimensional drawing showing cross sectional view and identification of components and their material specification, typical stator slot and rotor bar, shaft, fan, bearings etc*.		
16.11	Dimensional drawing of the terminal boxes showing dimensions, permissible cable size, degree of protection, materials of fabrication, etc and the method of terminating the purchaser's incoming cables*.		
16.12	Motor winding diagram attached?		
16.13	Motor equivalent circuit diagram showing stator and rotor resistance, leakage reactance and magnetizing reactance attached?		
16.14	Residual voltage at motor terminals versus time characteristics after supply disconnection to motor at full load*		
16.15	Measures taken to demonstrate adequacy of design of the drive train to withstand instantaneous torsional torque on account of fast transfer*		
16.16	Type test certificates to prove the specified fault withstand capability of power terminal box for both (a) internal faults and (b) external faults.		
16.17	List of dimension and material details of all gaskets and O' rings used in overall motor attached?		
16.18	Detailed procedure for assembly and disassembly of motor of		

.

Sl.No.	Particulars	
	each type and rating attached?	
17.0	**Additional Technical Particulars For High Voltage Induction Motors In Reactor Building**	
17.1	Applicable standards	
17.2	Is the motor designed to operate under normal and Loss of coolant accident/MSLB (accident) conditions?	Normal condition/ Normal and Accidental condition.
17.3	Capability of the motor to withstand specified radiation levels (Test certificate to be submitted for the insulating materials used).	
17.4	List of insulating materials used and their radiation withstand capability:	
17.4.1	Stator conductor	
17.4.2	Slot liner	
17.4.3	Slot wedge	
17.4.4	End connections	
17.4.5	Over hang portion	
17.4.6	Varnish/Resin for impregnation	
17.4.7	Motor terminals	
17.4.8	Gaskets	
17.4.9	Lubricants	
17.4.10	Control wires and accessories	
17.5	Capability of the motor to continuously operate under the specified accident conditions viz. temperature, pressure and relative humidity (Test certificate to be submitted or type test shall be performed as per approved procedure).	

Note:

a) All data sheets and characteristic curves should be strictly in the above format in A4 and A3 size sheets respectively with continuous page numbers, properly bound and provided with a cover sheet indicating names and signatures of persons responsible for preparation, checking, approving of documents at motor manufacturer, driven equipment vendor, EPC contractor etc before submission to the Purchaser. Alternatively characteristic curves can be submitted as separate documents in A3 size sheets. Document shall have Purchaser's purchase order reference, EPC contractor's purchase order reference and driven equipment vendor's purchase order reference, Purchaser's project identification, Motor tag numbers, revision number, date of revision etc on the cover sheet.

Motor manufacturer's name and address	**Date of issue, Rev No**

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b) All drawings shall be in A3 size sheets and shall indicate Purchaser's project identification, motor tag numbers, purchase order numbers etc.

c) Document detailing insulation system shall be a part of datasheet.

d) Items marked * can be submitted after placement of order and after completion of detailed engineering.

NUCLEAR POWER CORPORATION OF INDIA LIMITED

QUALITY ASSURANCE PLAN FOR 6.6kV MOTORS

Scope and Purpose:

This document indicates the requirements expected from the package contractor/manufacturer of motors. Subsequent to the placement of Purchase Order, contractor/manufacturer shall submit for purchaser's approval a quality assurance plan in line with this document incorporating specific document numbers for "format of records", "acceptance norms" and "reference documents" etc. If required by the purchaser, reference documents indicated shall be shown before approval of QAP.

QAP NO: PC-E-503/Annex-C.
DATE:July, 2018

R: Review H: Hold
P: Perform 1: NPCIL
W: Witness 2: Pakage Contractor
3: Motor Manufacturer/ External laboratory/manufacturer's Sub-contractor.

LEGEND

Manufacturer reference documents to be detailed here

AD: NPCIL Approved Document such as Tender Document, Purchase order, Drawings & Test Procedures

TR: Test Report
PS : Plant Standards
H: Hold Point
W: Witness (After lapse of due notice of 2 weeks time to NPCIL, manufacturer may proceed with manufacturing/next stage)
IS: Indian Standards
IEC : International Electrotechnical Commission standards
IEEE: Institute of Electronics and Electrical Engineers standards

NOTES:
* Wherever V & W are both indicated , NPCIL QS to witness test or review TRs at NPCIL's choice.
*** TRs not more than five year old from date of purchase order may be reviewed for acceptance. Otherwise, test shall be carried out at no extra cost to NPCIL and within the committed delivery schedule.**
* Minor: The characteristic of a component, process or operation whose failure neither materially reduce the usability of the product in operation, nor does it affect the aesthetic aspects.
* Major: The characteristic of a component, process or operation whose failure may cause operation failure which cannot be readily corrected at site or cause substandard performance, increased erection and maintenance cost, reduced life or seriously affect aesthetics or ergonomics.
* Critical: The characteristics of a component, process or operation failure of which will surely cause operating failure or intermittent troubles which is difficult to rectify at site or render the unit unfit for use or safety hazards.
* ''Failure '' of a characteristic means failure to meet the 'acceptance norms '.
* Sampling: Generally in accordance with IS:2500. If 100% "witness" is carried out by "Package contractor", NPCIL will witness on sample basis, or if 100% "witness" is carried out by "Motor Manufacturer", "Package contractor" will witness on sample basis.

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY R	AGENCY P	AGENCY W	AGENCY H	REMARKS
1	**Receiving Inspection**												
1.1	Stator Frame/Bracket, Terminal Box, Flywheel Housing	a) Chemical composition	Major	Chemical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3	2		TC to be furnished batchwise
		b) Mechanical properties (tensile, Yield & Elongation)	Major	Mechanical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3	2		
		c) Visual check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3	2		
		d) Dimensional Measurement	Major	Measurement	100%	Drawing	Drawing	TC	1, 2	3	2		
		e) Ultrasonic Testing of Plates for Stator Frames/Bracket with thickness more than 25mm	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1,2	3	2	1	10% Random by 1
1.2	Fan Assembly (Fan Hub & Blades)	a) Chemical composition	Major	Chemical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3	1, 2		
		b) Mechanical properties	Major	Mechanical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3	1, 2		
		c) Ultrasonic Testing	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3	1, 2		
		d) Radiography on Fan Blades	Major	NDT	100%	IS/PS	IS/PS	TC	1, 2	3	1, 2		
		e) DP test on Fan Blades	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3	1, 2		
1.3	Rotor Shaft & Ribs	a) Chemical composition	Major	Chemical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		b) Mechanical properties (tensile, Yield & Elongation)	Major	Mechanical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		c) Ultrasonic Testing of Plates	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3	1, 2		10% Random by 1
		d) Dimensional Measurement	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		e) DP test on welds	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3	1, 2		
1.4	Blank Fly Wheel	a) Chemical composition	Major	Chemical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		b) Mechanical properties	Major	Mechanical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
1.5	Bare Stator Copper Conductors	a) Chemical composition	Major	Chemical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		b) Mechanical properties	Major	Mechanical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		c) Electrical Resistivity	Major	Electrical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY R	AGENCY P	AGENCY W	AGENCY H	REMARKS
		d) Dimensional Measurement	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		e) Visual Check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
1.6	Insulating Material (Conductor tape, main insulating tape, end sealing tape, semi conducting tape etc.)	a) Dimensional Measurement	Major	Dimensional	1 Sample/Lot	Drawing	Drawing	TC	1, 2	3			
		b) Chemical composition	Major	Chemical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		c) Temperature class	Major	Test Report	100%	IS/Specification	IS/PS	TC	1, 2	3			
		d) BDV	Major	Electrical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
1.7	Stator/Rotor Core Stamping	a) Insulation Coat thickness	Major	Measurement	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		b) Chemical composition	Major	Chemical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		c) Mechanical properties	Major	Mechanical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		d) Bend test	Major	Mechanical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		e) Specific total loss measurement (before & after ageing)	Major	Electrical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		f) Unaged specimen magnetization	Major	Electrical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		g) Stacking factor	Major	Electrical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		h) Anisentropy losses	Major	Electrical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		i) Surface IR	Major	Electrical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
1.8	Rotor Copper Bar	a) Chemical composition	Major	Chemical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		b) Mechanical properties	Major	Mechanical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		c) Electrical Resistivity	Major	Electrical	100%	IS/PS	IS/PS	TC	1, 2	3			
		d) Dimensional Measurement	Major	Measurement	100%	Drawing	Drawing	TC	1, 2	3			
		e) DP test	Major	NDT	10%	NPCIL Procedure	NPCIL Procedure	TC	1,2	3	1, 2		
		a) Chemical composition	Major	Chemical	100%	IS/PS	IS/PS	TC	1, 2	3			
		b) Mechanical properties	Major	Mechanical	100%	IS/PS	IS/PS	TC	1, 2	3			

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY R	AGENCY P	AGENCY W	AGENCY H	REMARKS
1.9	Short Circuiting Ring	c) Electrical Resistivity	Major	Electrical	100%	IS/PS	IS/PS	TC	1, 2	3			
		d) Dimensional Measurement	Major	Measurement	100%	Drawing	Drawing	TC	1, 2	3			
		e) Visual Check	Major	Visual	100%	Drawing	Drawing	TC	1,2	3			
		f) Heat Treatment	Major	Mechanical	100%	IS/PS	IS/PS	TC	1,2	3			
		g) Ultrasonic test	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1,2	3			
		h) DP test	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1,2	3			
1.10	Rotor Core	a) Insulation Coat thickness	Major	Measurement	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		b) Chemical composition	Major	Chemical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		c) Mechanical properties	Major	Mechanical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		d) Bend test	Major	Mechanical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		e) Magnetic loss measurement	Major	Electrical	1 Sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		f) Surface IR	Major	Electrical	1 Sample/Lot	Drawing	Drawing	TC	1, 2	3			
1.11	Retaining Ring	a) Chemical composition	Major	Chemical	100%	Drawing	Drawing	TC	1, 2	3			
		b) Mechanical properties	Major	Mechanical	100%	Drawing	Drawing	TC	1, 2	3			
		c) Ultrasonic test	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
		d) DP test	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
1.12	Rotor End Plate	a) Dimensional check	Major	Dimensional	100%	IS/PS	IS/PS	TC	1, 2	3			
		b) Visual check	Major	Visual	100%	IS/PS	IS/PS	TC	1, 2	3			
		c) Mechanical properties	Major	Mechanical	100%	IS/PS	IS/PS	TC	1, 2	3			
		d) Chemical composition	Major	Chemical	100%	IS/PS	IS/PS	TC	1, 2	3			
		e) Ultrasonic test	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
1.13	RTDs	a) Temperature Calibration	Major	Measurement	100%	IS/PS	IS/PS	TC	1, 2	3			
		b) Dimensional check	Major	Dimensional	100%	IS/PS	IS/PS	TC	1, 2	3			
		c) Accuracy	Critical	Measurement	100%	IS/PS	IS/PS	TC	1, 2	3			

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SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY R	AGENCY P	AGENCY W	AGENCY H	REMARKS
1.14	Current Transformers	a) Verification of ratings	Critical	Visual	100%	IS/PS	IS/PS	TC	1, 2	3			
		b) Review of routine test certificates	Major	Review	100%	IS/PS	IS/PS	TC	1, 2	3			
		c) Review of type test certificates	Major	Review	Sample	IS/PS	IS/PS	TC	1, 2	3			
1.15	Space Heaters	a) HV test	Major	Electrical	100%	IS/PS	IS/PS	TC	1, 2	3			
		b) IR test	Major	Electrical	100%	IS/PS	IS/PS	TC	1, 2	3			
		c) Rating	Major	Measurement	100%	Drawing	Drawing	TC	1, 2	3			
		d) Performance test	Major	Testing	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
1.16	Pneumatic Brake Assembly	a) Mechanical Properties	Major	Mechanical	100%	IS/PS	IS/PS	TC	1, 2	3			
		b) Chemical composition	Major	Chemical	100%	IS/PS	IS/PS	TC	1, 2	3			
		c) DP test on Weld Surfaces	Critical	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3	1, 2		
		d) Performance test	Major	Testing	100%	Drawing	Drawing	TC	1, 2	3			
1.17	Bearings & Bearing Housings	a) Visual check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		b) Dimensional check	Major	Dimensional	100%	IS/PS	IS/PS	TC	1, 2	3			
		c) DP test on weld surfaces	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
		d) RT on Bearing Pad housing (Casting)	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
		e) UT on Plates (>25mm)	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
1.18	Coolers	a) Mechanical Properties	Major	Mechanical	100%	IS/PS	IS/PS	TC	1, 2	3			
		b) Chemical composition	Major	Chemical	100%	IS/PS	IS/PS	TC	1, 2	3			
		c) Dimensional check	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		d) Visual check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		e) DP test on welds	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
1.19	Power Terminal Box	a) Visual & dimensional check	Major	Visual & dimensional	100%	Test Report	Test Report	TC	1, 2	3			
		b) Review of type test reports	Major	Review	Sample	IS/Drawing	IS/Drawing	TC	1, 2	3			Review of type test report.

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SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY R	AGENCY P	AGENCY W	AGENCY H	REMARKS
		c) Compliance to type tested terminal boxes	Major	Review	Sample	IS/Drawing	IS/Drawing	TC	1, 2	3			
1.20	Slot Wedge	a) Verification of test certificate for Mechanical & Electrical tests	Major	Review	Sample	IS/Drawing	IS/Drawing	TC	1, 2	3			
2	**In-Process Inspection**												
2.1	Stator Frame/Bracket, Terminal Box, Flywheel Housing Fabrication	a) Use of Qualified Welder	Major	Process	Record verification	PS	PS	TC	1, 2	3			TC to be furnished batchwise
		b) Visual examination of weld seams	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		c) DP test on Welds	Major	NDT	100% of accessible area	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3	1, 2		
		d) Heat Treatment	Major	Mechanical	100%	IS/PS	IS/PS	TC	1, 2	3	1, 2		
	Stator Frame/Bracket, Terminal Box, Flywheel Housing Machining	a) Dimensional Measurement	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		b) Visual check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		c) MPI on load bearing surfaces of Frame & Flywheel Housing	Major	NDT	100%	IS/PS	IS/PS	TC	1, 2	3	1, 2		
		d) Run out measurement on stator concentricity and fan	Major	Measurement	100%	IS/PS	IS/PS	TC	1, 2	3	1, 2		
2.2	Fan Assembly (Fan Hub & Blades) Fabrication	a) Use of Qualified Welder	Major	Process	Record verification	PS	PS	TC	1, 2	3			TC to be furnished batchwise
		b) Visual examination of weld seams	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		c) DP test on Welds	Major	NDT	100% of accessible area	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3	1, 2		
		d) Heat Treatment	Major	Mechanical	100%	IS/PS	IS/PS	TC	1, 2	3	1, 2		
	Fan Assembly (Fan Hub & Blades) Machining	a) Dimensional Measurement	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		b) Visual check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			

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SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY				REMARKS
									R	P	W	H	
		c) Concentricity & run out of Fan	Major	Measurement	100%	IS/PS	IS/PS	TC	1, 2	3	1, 2		
2.3	Rotor Shaft & Ribs Fabrication	a) Use of Qualified Welder	Major	Process	Record verification	PS	PS	TC	1, 2	3			
		b) Visual examination of weld seams	Major	Visual	100%	IS/PS	IS/PS	TC	1, 2	3			
		c) DP test on weld seams	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3		1	
		d) Stress Relieving	Major	Process	100%	IS/PS	IS/PS	TC	1, 2	3			
		e) Steel melting for Shaft Blank	Major	Spectrometric	1 sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		f) Ingot & Forging for shaft blank	Major	Dimensional	1 sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		g) Heat treatment for shaft blank	Major	Process	1 sample/Lot	IS/PS	IS/PS	TC	1, 2	3			
		h) Mechanical properties (tensile/impact on both ends)	Major	Mechanical	1 sample/Lot	IS/PS	IS/PS	TC	1, 2	3	1, 2		
		i) Ultrasonic test	Major	NDT	1 sample/Lot	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3		1	
		j) Dimensioanl check	Major	Dimensional	1 sample/Lot	Drawing	Drawing	TC	1, 2	3	1, 2		
	Rotor Shaft & Ribs Machining	a) DP test on entire machined sutface of shaft & ribs	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3	1, 2		
		b) Dimensional check including contact area checking by Ring Gauge	Major	Measurement	100%	IS/PS/Drawing	IS/PS/Drawing	TC	1, 2	3		1	
		c) Surface finish, run out & concentricity	Major	Visual/Measurement	100%	Drawing	Drawing	TC	1, 2	3			
		d) Visual check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
2.4	Auxiliary Shaft for Flywheel Balancing	a) Dimensional Measurement	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		b) Contact area checking by Ring Gauge	Major	Measurement	100%	IS/PS/Drawing	IS/PS/Drawing	TC	1, 2	3	1, 2		
		a) Dimensional Measurement	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		b) Run out measurement	Major	Measurement	100%	Drawing	Drawing	TC	1, 2	3		1	

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SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY R	AGENCY P	AGENCY W	AGENCY H	REMARKS
	Fly Wheel Machining	c) Examination of Taper Bore contact area with plug guage	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		d) DP test for bore & balancing groove	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3		1	
		e) Ultrasonic after machining	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3		1	
		f) MPI excluding bore, balancing groove	Major	NDT	100%	IS/PS	IS/PS	TC	1, 2	3		1	
2.5	Fly Wheel Balacing	a) Balancing of Flywheel (On Auxiliary Shaft) at 1200rpm	Major	Testing	100%	IS/PS	IS/PS	TC	1, 2	3		1	
		b) Overspeeding at 1875rpm for 2 minutes and balancing check at 1200rpm	Major	Testing	100%	IS/PS	IS/PS	TC	1, 2	3		1	
		c) Checking of surface roughness	Major	Measurement	100%	Drawing	Drawing	TC	1, 2	3		1	
		d) DP test for bore & balancing groove	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3		1	
		e) Ultrasonic after balancing	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3		1	
		f) MPI excluding bore, balancing groove	Major	NDT	100%	IS/PS	IS/PS	TC	1, 2	3		1	
		g) Visual Inspection	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
2.6	Stator Coil Manufacturing	a) Dimensional Measurement	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		b) Visual check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		c) Inter turn test	Major	Electrical	100%	IS/PS	IS/PS	TC	1, 2	3			
		d) DC HV test including IR measurement	Major	Electrical	100%	IS/PS	IS/PS	TC	1, 2	3			
		e) Power frequency voltage test	Major	Electrical	2 samples/Coil	IS/PS	IS/PS	TC	1, 2	3		1	
		f) Impulse Voltage withstand test	Major	Electrical	2 samples/Coil	IS/PS	IS/PS	TC	1, 2	3		1	
		a) Dimensional Check	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			

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SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY R	AGENCY P	AGENCY W	AGENCY H	REMARKS
2.7	Stator Main Stamping	b) Burr Checking	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		c) Insulation coat thickness	Major	Measurement	2 Samples/Lot	IS/PS	IS/PS	TC	1, 2	3	1, 2		
2.8	Stator Vent Stamping	a) Dimensional Measurement	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		b) Visual Check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		c) Quality of projection welding of spacers	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
2.9	Stator/Rotor End Plate	a) Mechanical Properties	Major	Mechanical	100%	IS/PS	IS/PS	TC	1, 2	3			
		b) Chemical composition	Major	Chemical	100%	IS/PS	IS/PS	TC	1, 2	3			
		c) Dimensional check	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		d) Ultrasonic test of rotor end plate (>30mm Min.)	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3		1	
		e) Visual check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
2.10	Stator Core	a) Dimensional check	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		b) DP on load bearing machined surface	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
		c) Compactness of core	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		d) Visual check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		e) Check Slot size by gauge	Major	Measurement	100%	Drawing	Drawing	TC	1, 2	3			
		f) Hot spot measurement at 1 Tesla	Critical	Measurement	1 Sample	IS/PS	IS/PS	TC	1, 2	3	1, 2		
2.11	Short Circuiting Ring Machining	a) DP test on SC Ring (on joint machined)	Major	NDT	10%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3	1, 2		
2.12	Retaining Ring Machining	a) Dimensional check	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		b) Visual check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		c) DP test	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3	1, 2		

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SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY				REMARKS
									R	P	W	H	
2.13	Rotor Main Stamping	a) Dimensional Check	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		b) Burr Checking	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
2.14	Rotor Vent Stamping	a) Dimensional Measurement	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		b) Visual Check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		c) Quality of projection welding of spacers	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
2.15	Rotor Core	a) Dimensional check	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		b) Slot size check with gauge	Major	Measurement	100%	IS/PS	IS/PS	TC	1, 2	3			
		c) Compactness of core	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		d) Hot spot measurement	Critical	Measurement	1 Sample	IS/PS	IS/PS	TC	1, 2	3	1, 2		
		e) Smoothness of internal slots	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
2.16	Wound Rotor (SC Ring Bracing)	a) Check record of approved bracing process & qualified bracers	Major	Record verification	100%	PS	PS	TC	1, 2	3			
		b) Preparatory check before bracing	Major	Visual	100%	IS/PS	IS/PS	TC	1, 2	3			
		c) Visual inspection of braced joints & process control during bracing	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		d) Ultrasonic test of braced joints	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3		1	
		e) Dimensional check	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3			
		f) Run out & concentricity check for journal & coupling diameter	Major	Measurement	100%	IS/PS	IS/PS	TC	1, 2	3		1	
2.17	Wound Rotor with Fan	a) Balancing at rated speed	Major	Testing	100%	IS/PS	IS/PS	TC	1, 2	3	1, 2		

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									R	P	W	H	
2.18	Rotor Assembly	a) Dynamic balancing of rotor complete with fans flywheel, brakes hub & dics and pole wheel assembly at rated speed and overspeed at 120% of rated speed for 2 minutes	Major	Testing	100%	IS/PS	IS/PS	TC	1, 2	3		1	
2.19	Flywheel Mounting on Shaft	a) Ultrasonic of flywheel for detection of contact area between flywheel & shaft	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3		1	
2.20	Wound Stator	a) RTD resistance measurement before laying of coil	Major	Measurement	100%	IS/PS	IS/PS	TC	1, 2	3			
		b) Check stator bracing & overhang arrangement	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
2.21	Stator Winding	a) Interturn testing	Major	Electrical	100%	IS/PS	IS/PS	TC	1, 2	3	1, 2		
		b) DC HV test after bracing	Critical	Electrical	100%	IS/PS	IS/PS	TC	1, 2	3	1, 2		
2.22	Stator Bracing	a) Phase resistance measurement	Major	Measurement	100%	IS/PS	IS/PS	TC	1, 2	3	1, 2		
		b) Polarity test	Major	Measurement	100%	IS/PS	IS/PS	TC	1, 2	3			
2.23	VPI Process	a) Check record of resin/varnish viscosity	Major	Record verification	100%	PS	PS	TC	1, 2	3			
		b) Impregnated resin and hardner as per specification	Major	Record verification	100%	PS	PS	TC	1, 2	3			
2.24	Wound stator after VPI	a) IR & PI of winding after VPI	Major	Electrical	100%	IS/PS	IEEE std 43/IEC 60034-27	TC	1, 2	3			
		b) Resistance & IR of RTDs after VPI	Major	Electrical	100%	IS/PS	IS/PS	TC	1, 2	3			
		c) Winding resistance measurement after VPI	Major	Electrical	100%	IS/PS	IS/PS	TC	1, 2	3			

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									R	P	W	H	
2.25	Bearing and bearing housing	UT of Bearing Pads after forging and before babbitting	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
		UT & DP test of Bearing Pads after babbitting	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
		DP test of Bearing Pads after machining	Major	NDT	100%	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
2.26	Other accessories and auxiliaries	Review of test reports	Major	Review	100%	IS/PS	IS/PS	TC	1, 2	3			
		Review of environmental qualification reports	Major	Review	100%	IS/PS	IS/PS	TC	1, 2	3			
		Functional verification	Major	Testing	100%	IS/PS	IS/PS	TC	1, 2	3	1, 2		
2.27	Reverse rotation ratchet (if provided)	Verification of mechanical properties of materials used	Major	Mechanical	1sample / lot	IS/PS	IS/PS	TC	1, 2	3			
		Verification of chemical properties of materials used	Major	Chemical	1sample / lot	IS/PS	IS/PS	TC	1, 2	3			
		Examination of welds, welding process, and welders	Critical	NDT	1sample / lot	NPCIL Procedure	NPCIL Procedure	TC	1, 2	3			
		Functional tests	Major	Testing	100%	IS/PS	IS/PS	TC	1, 2	3	1, 2		
3	**Tests**												
3.1	Motor Assembly	a) Visual check	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		b) Check for completeness & accessories	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3			
		c) Mounting & Dimensional check	Major	Dimensional	100%	Drawing	Drawing	TC	1, 2	3	1, 2		
		d) Runout of shaft extension, spigot and flange	Major	Mechanical	100%	Drawing	Drawing	TC	1, 2	3	1, 2		
		e) Measurement of bearing clearances	Major	Measurement	100%	Drawing	Drawing	TC	1, 2	3	1, 2		
		f) Air gap measurement (Stator ID & Rotor OD)	Major	Measurement	100%	Drawing	Drawing	TC	1, 2	3	1, 2		
		a) IR of winding before and after HV test	Major	Electrical	100%	IS	IS	TC	1, 2	3		1, 2	

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SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY				REMARKS
									R	P	W	H	
3.2	Routine Test	b) HV test	Major	Electrical	100%	IS	IS	TC	1, 2	3		1, 2	
		c) Winding Resistance measurement	Major	Electrical	100%	IS/Drawing	IS/Drawing	TC	1, 2	3		1, 2	
		d) IR & HV on space heater and winding RTD	Major	Electrical	100%	IS/Drawing	IS/Drawing	TC	1, 2	3		1, 2	
		e) Phase sequence & direction of rotation	Major	Electrical	100%	IS/Drawing	IS/Drawing	TC	1, 2	3		1, 2	
		f) Locked rotor test	Major	Electrical	100%	IS	IS	TC	1, 2	3		1, 2	
		g) Reduced voltage running test on no load	Major	Electrical	100%	IS	IS	TC	1, 2	3		1, 2	
		h) No load test and bearing temp. rise	Major	Electrical	100%	IS	IS	TC	1, 2	3		1, 2	
		I) Shaft voltage	Major	Electrical	100%	IS/Drawing	IS/Drawing	TC	1, 2	3		1, 2	
		j) Polarisation index	Major	Electrical	100%	IS	IS	TC	1, 2	3		1, 2	
		k) Noise level on No load	Major	Electrical	100%	IS	IS	TC	1, 2	3		1, 2	
		l) Vibration on No Load	Major	Electrical	100%	IS	IS	TC	1, 2	3		1, 2	
		m) Functional checks on all accessories and auxiliaries	Major	Electrical	100%	Drawing	Drawing	TC	1, 2	3		1, 2	
		n) Completeness	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3		1, 2	
		o) Terminal marking and rating plate details	Major	Visual	100%	Drawing	Drawing	TC	1, 2	3		1, 2	
		p) Overspeed test at 120% rated speed for 2 min.	Major	Electrical	100%	IS	IS	TC	1, 2	3		1, 2	
		q) Functional check on vibration monitoring system	Major	Electrical	100%	Drawing	Drawing	TC	1, 2	3		1, 2	
3.3	Type Tests (In addition to all tests mentioned in routine test)	a) Temp. rise test at approx -10% of rated voltage as per mixed frequency test method as given in JEC-37	Major	Electrical	On one motor	PS/JEC-37	PS/JEC-37	Test Report	1, 2	3		1, 2	

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY				REMARKS
									R	P	W	H	
		b) Load test and derivation of performance data corresponding to 50%, 75% and 100% load at rated voltage	Major	Electrical	On one motor	IS	IS	Test Report	1, 2	3		1, 2	
		c) Operation of motor on full load at 70% voltage for 1 second & 80% voltage for 10 min.	Major	Electrical	On one motor	IS	IS	Test Report	1, 2	3		1, 2	
		d) Test for degree of protection by enclosures of motor and terminal box.	Major	Mechanical	On one motor	IS/Drawing	IS/Drawing	Test Report	1, 2	3		1, 2	In case of large frame size motors, second numeral test shall be conducted in test lab/motor manufacturer's premises in presence of NPCIL QA, whereas for first numeral test either vendor can submit analysis report indicating dimensional details, material details and design details to meet the first numeral test criteria or can test a similar construction type motor of smaller frame size. The acceptance of first numeral test report on smaller frame size motor or analysis report on same motor shall be subject to Purchaser's review and approval.
		e) Recording of motor terminal voltage decay after switching off of the input supply voltage	Major	Electrical	On one motor	IS/Drawing	IS/Drawing	Test Report	1, 2	3		1, 2	
		f) Recording of motor speed decay after switching of the input supply voltage	Major	Electrical	On one motor	IS/Drawing	IS/Drawing	Test Report	1, 2	3		1, 2	
		g) Calculation of starting & pull out torque and starting current at reduced voltage	Major	Electrical	On one motor	IS/Drawing	IS/Drawing	Test Report	1, 2	3		1, 2	
		h) Determination of moment of inertia	Major	Electrical	On one motor	IS/Drawing	IS/Drawing	Test Report	1, 2	3		1, 2	

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY				REMARKS
									R	P	W	H	
		i) tan delta & delta tan delta on stator winding at room temperature	Major	Electrical	On one motor	IS/PS	IS/PS	Test Report	1, 2	3		1, 2	Test conducted during stator coil manufacturing stage is acceptable
		j) Momentary overload test at 160% of current for 15 seconds by Mixed Frequency Heat Run method	Major	Electrical	On one motor	IS	IS	Test Report	1, 2	3		1, 2	
4.0	Pre despatch Inspection	a) Painting finish	Major	Visual	100%	Approved GA Drg.	Approved GA Drg.	PS		3	2	1	
		b) Review of end documents & issue of shipping release	Major	Review of all doc. For each motor	100%	Approved documents	Approved documents	PS		3	2	1	
5.0	If specified in Annexure-A, special tests required to demonstrate capability of motors to perform in the anticipated ambient conditions due to radiation, LOCA and MSLB shall be performed in accordance with an approved procedure and reports submitted to NPCIL. All other qualification and testing shall meet the pump specifications.												

NUCLEAR POWER CORPORATION OF INDIA LTD
(A Government of India Enterprise)

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1.0 CONTENTS

The specification has been presented under the following Sections and Annexures:

Section	Title
1	Contents
2	Scope
3	Definitions
4	Introduction
5	Applicable codes and standards
6	Qualification methods and procedures.
7	Specification for qualification of valves.
8	Specification for qualification of panels and devices.
9	Specification for qualification of rotating and reciprocating equipment
10	Specification for qualification of tanks, vessels, heat exchanger and their supports.

Annexure-1	Load Combinations for Design Condition and Service Levels for Equipment and Supports
Annexure-2	General design guideline for equipment
Annexure-3	List of shake table test facilities in India
Annexure-4	Static side load test
Annexure-5	Sample Seismic Test Procedure for Valve/Valve actuator/ Instrument/Device
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2.0 SCOPE

This specification describes methods and procedures for seismic qualification of Structures, Systems and Components (SSC) of a nuclear power plant. The methods and procedures described in section 6 are applicable to all SSC of a NPP. However, detailed procedures for seismic qualification of certain equipment viz. valves; electrical and Instrumentation & control equipment; rotating and reciprocating equipment; passive systems/equipment like tanks, vessels and heat exchangers are described in sections 7,8,9 & 10 of this specification. Qualification of primary civil structures and piping are excluded from the scope of this specification.

3.0 DEFINITIONS

3.1 Cut-off Frequency: The frequency in the response spectrum where the Zero Period Acceleration asymptote essentially begins. This is the frequency beyond which the single-degree-of-freedom oscillators exhibit very little or no amplification of motion and indicates the upper limit of the frequency content of the waveform being analyzed.

3.2 Damping: An energy dissipation mechanism that reduces the amplification and broadens the vibratory response in the region of resonance. Damping is usually expressed in terms of percentage of critical damping. Critical damping is defined as the least amount of viscous damping that causes a SDOF system to return to its original position without oscillation after initial disturbance.

3.3 Design Condition: The design conditions include those pressure, temperature, and mechanical loadings selected as the basis for the design of systems, structures or components within a facility.

3.4 Design Basis Events: The set of events which serves as part of the basis for the establishment of design requirements for systems, structures and components within a facility. Design basis events (DBEs) include normal operations, operational transients and certain accident conditions under postulated initiating events (PIE) considered in the design of the facility.

3.5 Level A Service Limits (Normal Operating Conditions): Level A Service Limits are those sets of limits that must be satisfied for all Level A Service Loadings identified in the Design Specifications to which the component or support may be subjected in the performance of its specified service function.

Normal Operation of a plant or equipment within specified operational limits and conditions. In case of a nuclear power plant, this includes, start-up, power operation, shutting down, shutdown state, maintenance, testing and refuelling.

3.6 Level B Service Limits (Upset Conditions): Level B Service Limits are those sets of limits that must be satisfied for all Level B Service Loadings identified in the Design Specifications for which these Service Limits are designated. The component or support must withstand these loadings without damage requiring repair.

All operation processes deviating from normal operation which are expected to occur once or several times during the operating life of plant that and which, in view of appropriate design provisions do not cause any significant damage to items important to safety nor lead to accident conditions.

3.7 Level C Service Limits (Emergency Condition): Level C Service Limits are those sets of limits that must be satisfied for all Level C Service Loadings identified in the Design Specifications for which these Service Limits are designated. These sets of limits permit large deformations in areas of structural discontinuity that may necessitate the removal of the component or support from service for inspection or repair of damage to the component or support. Level-C service Loadings has a low probability of occurrence.

3.8 Level D Service Limits (Faulted Condition): Level D Service Limits are those sets of limits that must be satisfied for all Level D Service Loadings identified in the Design Specifications for which these Service Limits are designated. These sets of limits permit gross general deformations with some consequent loss of dimensional stability and damage requiring repair, that may require removal of the component or support from service. Level-D service Loadings has extremely low probability of occurrence.

3.9 Response spectrum: A plot of the maximum response, as a function of oscillator frequency, of an array of Single Degree Of Freedom (SDOF) damped oscillators subjected to the same base excitation.

3.10 Required Response Spectrum (RRS): The response spectrum issued by the user or the user's agent as part of the specifications for qualification or artificially created to cover future applications. The RRS constitutes a requirement to be met for seismic qualification of equipment by shake table testing.

3.11 Rigid Equipment: Equipment, structures, and components whose lowest natural frequency is greater than the cut-off frequency on the response spectrum.

3.12 Seismic Anchor Movement (SAM): Seismic anchor movement (or "SAM") is the differential motion between pipe support attachment points (for example,

supports attached to an upper floor would sway with the building, with a larger amplitude than supports attached at a lower elevation), or the differential motion between equipment nozzles and pipe supports. Seismic anchor movements are input as displacements (translations and rotations) at the support attachments or at equipment nozzles. The resulting stresses and loads in the piping system are then combined by square root sum of the squares (SRSS) to the stress and loads due to inertia.

3.13 S1 Level Earthquake - Operating Basis Earthquake (OBE): An earthqauke which, considering the regional and local geology and seismology and specific characteristics of local sub-surface material, could reasonably be expected to affect the plant site during the operating life of plant. The features of nuclear power plant necessary for continued safe operation are designed to remain functional, during and after the vibratory ground motion caused by this earthquake.

3.14 S2 Level Earthquake - Safe Shutdown Earthquake (SSE) : The earthquake which is based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology and specific characteristics of local sub-surface material. It is that earthquake which produces the maximum vibratory ground motion for which certain structures, systems and components are designed to remain functional. These structures, systems and components are those which are necessary to assure

a) The integrity of reactor coolant pressure boundary; or
b) The capability to shutdown the reactor and maintain it in a safe shutdown condition; or
c) The capability to prevent the accident or to mitigate the consequences of accidents which could result in potential off-site exposures higher than the limits specified by the Regulatory Body; or
d) The capacity to remove residual heat.

3.15 Seismic Category-1 : Seismic category-1 shall includes all SSCs

a) Whose failure could directly or indirectly cause accident conditions, or
b) Which are required for shutting down the reactor, monitoring critical parameters, maintaining it in a safe shutdown condition and removing decay heat on a long term basis, or
c) Which are required to prevent radioactive releases or to maintain release below limits established by AERB for accident conditions(e.g. containment system).

All seismic category-1 structures, systems and components should be designed or qualified for both S1 (OBE) and S2 (SSE).

3.16 **Seismic category-2** : Seismic category-2 shall includes all SSCs which are required to:

a) Prevent the escape of radioactivity beyond the limits prescribed for normal operation and not covered in category-1, or
b) Mitigate those accident conditions which last for such long periods that there is a reasonable likelihood of an earthquake of the defined severity occurring during this period and not covered in category-1.

All seismic category-2 structures, systems and components shall have demonstrated capability to withstand the effects of S1 (OBE).

3.17 **Seismic category-3**: Seismic category-3 includes SSCs which are not important to safety and those not covered in category 1 or 2.

3.18 **Test response spectrum (TRS)** : The response spectrum that is developed from the actual time history motion given to the shake table.

3.19 **Zero Period Acceleration (ZPA)**: The acceleration level of the high frequency, non amplified portion of the response spectrum. This acceleration corresponds to the maximum peak acceleration of the time history used to derive the response spectrum.

4.0 INTRODUCTION:

A Nuclear Power Plant (NPP) has variety of Structures, Systems and Components (SSC) comprising primary civil structures and secondary structures, systems and components viz., tanks, vessels, heat exchangers, piping, supports; valves; pumps, fans, blowers, motors; compressors, diesel generators, reciprocating pumps; instrumentation and electrical panels, instrumentation and electrical devices, reactor control and shutdown devices, etc. These NPP structures, systems and components are designed and qualified for various service conditions viz. design, normal, upset (pressure, temperature, mechanical, transients), emergency, faulted (pressure, mechanical) and test conditions as applicable, including natural phenomenon like earthquake. The seismic design considers two levels of earthquake i.e. Operating Basis Earthquake OBE (S1) alone or OBE (S1) and Safe Shutdown Earthquake SSE (S2) as specified. Design of structures, systems and components for dead weight, sustained loads, pressure and temperature and mechanical loads is a standard industrial design practice. However, seismic design is a special branch of engineering and has been specifically dealt within this specification.

The General guidelines for seismic design are given in Annexure-2.

As specified in the NPCIL's equipment specifications, for the qualification of an equipment, following requirements shall be met:

i) Structural integrity and pressure boundary integrity
and
ii) Intended functional operability as applicable.

The seismic qualification of structures, system and components should establish that the structures, systems or components perform their intended safety functions during and after the specified earthquake(s). The examples of safety functions are structural integrity, degree of leak tightness, mechanical or electrical functional operability, preservation of geometrical dimensions or combination of these and any other specified function related to the specific structure, system or component under consideration. The seismic analysis should be based on clear understanding of the functions which should be assured during or after the specified earthquake(s).

Various structures, systems and components are classified into either seismic category 1 or seismic category 2 or seismic category 3. Items in category 1 should be designed for both S1 (OBE) and S2 (SSE) level earthquake ground motions. Items in category 2 should be designed for S1 (OBE) level earthquake ground motions. Seismic category 3 items should be designed for earthquake resistance according to the National practice. Loads during normal operation, anticipated operational occurrences, and loads during accident conditions should be combined with specified seismic loads as applicable. The allowable limits for stresses and

deformations under different load combinations should be used to assess the safety function and design intent as per the applicable code or specification of the structure, system and component.

For passive equipment viz., tanks, vessels, heat exchangers and supports qualification requirement are structural integrity and pressure boundary integrity. However, for active equipment viz., valves; pumps, fans, blowers, motors; compressors, diesel generators; electrical and instrumentation panels and devices involving mechanical motion, the qualification requirements shall also include functional operability.

This specification covers the procedure for qualification of secondary support structures, systems and components except civil structures, piping, to meet the above qualification requirements. For an equipment any specific requirement, other than the general requirement specified in the code shall also be met.

5.0 APPLICABLE CODES AND STANDARDS

Applicable codes and standards for design and qualification of various structures, systems and equipment are given below.

5.1. ASME Boiler and Pressure Vessel code, Section-III, Division-1, Subsection NB, Class 1 components, 2012.

5.2. ASME Boiler and Pressure Vessel code, Section-III, Division-1, Subsection NC, Class 2 components, 2012.

5.3. ASME Boiler and Pressure Vessel code, Section-III, Division-1, Subsection ND, Class 3 components, 2012.

5.4. ASME Boiler and Pressure Vessel code, Section-III, Division-1, Subsection NF, Component Supports, 2012.

5.5. ASME Boiler and Pressure Vessel code, Section-III, Division-1, Appendices, 2012.

5.6. ASME Boiler and Pressure Vessel code, Section-VIII, Pressure Vessels, Division 1, 2012.

5.7. ASME Boiler and Pressure Vessel code, Section-VIII Pressure Vessels, Division 2, Alternative Rules 2012.

5.8. ASME/ANSI B-31.1, Code for Power Piping, 2010

5.9. ASME Boiler and Pressure Vessel code section II, Material Specifications, 2012.

5.10. ACI 349-85, Code Requirements for Nuclear Safety Related Concrete Structures and commentary ACI-349 R-85, 1985.

5.11. ASCE 4-98, Seismic Analysis of safety related nuclear structures and commentary on standard for seismic analysis of safety related nuclear structures, 1998.

5.12. IS-800, Code of practice for use of structural steel in general building construction, 2007.

5.13. IS-456, Code of practice for plain and reinforced concrete, 2000.

5.14. Mechanical standard TEMA, class C, 2007.

5.15. Welding Research council bulletin WRC 107, Local stresses in spherical and cylindrical shells due to external loading, 2002.

5.16. Welding Research Council bulletin WRC 297, Local stresses in cylindrical shells due to external loading on nozzle, 1987.

5.17. Combined modal response and spatial components in seismic response analysis USNRC RG 1.92, 2006.

5.18. USNRC RG 1.100 revision 3 "Seismic Qualification of Electrical & Active Mechanical equipment and Functional Qualification of Active Mechanical equipment for Nuclear Power Plants", September 2009.

5.19. Paper on response combination by R.P.Kennedy, NUREG 1061 Vol. 4, Appendix A of SMA 1211.02.R2.0, March 1984.

5.20. NUREG/CR-6241, BNL-NUREG-52422, Technical guidelines for Aseismic design of Nuclear Power Plants, 1994.

5.21. IEEE Std-344, IEEE recommended practice for seismic qualification of Class 1E equipment for nuclear power generating stations, 2013.

5.22. IEEE Std-382, IEEE standard for qualification of actuators for power operated valve assemblies with safety related function for Nuclear Power Plants, 2006.

5.23. IEC-60780, Nuclear Power Plants – Electrical equipment of the safety system qualification, 1998.

5.24. IEC-60980, Recommended practice for seismic qualification of electrical equipment of the safety system for nuclear generating stations, 1998.

5.25. ASME QME 1-2007 Qualification requirements for active mechanical equipment for nuclear power plants, 2012.

5.26. IAEA Safety Guide 50-SG-S2, Seismic analysis and testing of Nuclear Power Plants, 1980.

5.27. IEEE C37.98-1987, IEEE standard Seismic Testing of Relays.

5.28. IS-1893, Criteria for earthquake resistant design of structures, 2002.

5.29. IEEE-693 - IEEE recommended practice for Seismic Design of sub-stations, 2005.

5.30. ACI-318/318 R-95: Building Code Requirement for Structural Concrete and Commentary.

5.31. IEEE-420 – IEEE Standard for design of class 1E Electrical Boards, Panels, Racks, 2001.

5.32. AERB Guide No. AERB/NPP-PHWR/SG/D-23 Seismic Qualification of Structures, Systems and Components of Pressurised Heavy Water Reactors, 2009.

5.33. AERB SAFETY GUIDE NO. AERB/NPP-PHWR/SG/D-1 Safety Classification and Seismic Categorisation for Structures, Systems and Components of Pressurised Heavy Water Reactors, 2003.

5.34. USNRC RG 1.29 Revision 3 "Seismic Design Classification", September 1978.

5.35. USNRC RG 1.26 Revision 4 "Quality Group Classifications and Standards for Water, Steam and Radioactive Waste Containing Components of Nuclear Power Plants", March 2007.

5.36. IEEE-323 – IEEE Standard for qualifying class 1E Equipments for Nuclear Power Generating Station, 2001.

5.37. U.S. Atomic Energy Commission, "Nuclear Reactors and Earthquakes", TID-7024, Washington, D.C., 1963.

5.38. Program on technology innovation, "The effects of high frequency ground Motion on structures, components, and Equipment in nuclear power plants" EPRI, June 2007.

5.39. EPRI Draft White Paper, "Considerations for NPP Equipment and Structures Subjected to Response Levels Caused by High Frequency Ground Motions", March 2007.

5.40. "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions", EPRI White Paper, June 2007.

5.41. "Seismic Design and Retrofit of Piping Systems", ASCE, July2002.

5.42. "Seismic Evaluation Procedure for Equipment in US Department of Energy Facilities DOE/EH-0545, March 1997.

The codes and standards referred above or any of their latest revisions can be used in concurrence with NPCIL. The general requirements of other standards and codes or guides applicable for manufacture, design and qualification for specific equipment which are not listed above shall also be met. For example IEEE-387 guide for emergency diesel generator sets, IEEE-628 for cable trays, IS-9000 for environmental qualification of electrical & instrumentation etc.

6.0 SEISMIC QUALIFICATION METHODS AND PROCEDURES

The seismic qualification in terms of structural and pressure boundary integrity and /or functional operability as applicable can be performed by any of the following commonly used methods viz.,

a) Analysis
b) Testing
c) Analysis and Testing

These methods, or other justifiable methods, may be adequate to verify the ability of the SSC to meet the seismic qualification requirements. The choice should be based on the practicality of the method for the type, size, shape, complexity of the SSC configuration, whether safety function can be assessed in terms of structural integrity/pressure boundary integrity alone and/or in terms of functional operability.

6.1 Qualification for Structural and Pressure Boundary Integrity

Qualification of SSCs, whether passive or active, can be performed by analysis to assess their intended function in terms of structural integrity and pressure boundary integrity as per the requirements of governing code.

6.1.1 Qualification by Analysis using Simplified Method

Wherever feasible analytical methods using classical bending and direct stress equations, where free body diagram determine a simple stress distribution that is in equilibrium with applied loads may be used with prior approval from NPCIL. Empirical formulae and equations as given in relevant codes & guides for specified equipment may be used.

6.1.2 Qualification by Analysis using FEM

Qualification of SSCs are required to be performed for various loads viz., design loads, loads during normal and upset conditions (pressure, temperature, mechanical, cycles, transients), including OBE; loads during emergency and faulted conditions (pressure, mechanical) including SSE; test loads; etc. as specified in NPCIL's equipment specification and in the Vendor's General Equipment Specification (VGES).

The general steps involved to meet the qualification requirements are:

i) Preparation of the finite element model which represents the SSC adequately.

The guidelines on modeling are given in para 6.1.2.1

ii) Identification of the applicable loads.

iii) Determination the structural response for these loads in terms of forces, moments, displacements and stresses. The seismic response shall be determined by using response spectrum analysis/time history analysis/ equivalent static analysis method.

iv) Combination of the seismic responses with other operating stresses and displacements as per the load combinations given in Annexure-1.

v) Comparison of the combined stresses and displacements with those that ensure compliance with design/ codal requirements. The stresses and displacements shall be less than allowable values.

6.1.2.1 FEM Modeling

Seismic analysis of SSCs generally uses Finite Element (FE) methods. Most of the commercially available computer codes have the capability to perform the analysis. The following are some of the acceptable methods of modeling the SSC.

i. Finite Element Model using Beam or One-Dimensional Element

This modeling is typically applied to beams, columns, frames, ducts, cable trays, conduits, cabinets, storage racks, which are expressed as a continuous or one dimensional finite element in a two or three- dimensional space. Masses are represented by lumped parameters, which develop a diagonalised elemental mass matrix. Tanks, pressure vessels and heat exchangers can also be modelled this way, especially when using the equivalent static method.

ii. Finite Element Model using Plate & Shell Element

This type of modeling is adopted for items whose primary mode of failure is by biaxial bending stress, plane stress or plane strain. Typically included in this category are : cabinets, tanks, pressure vessels and heat exchangers whose shells support significant eccentric loads which would tend to excite shell or local modes of vibration.

iii. Finite Element Model using Solid Element

In this, the SSC is modeled by using solid elements. This type of modeling is expensive and is preferable for local analysis to obtain correct stress picture at openings, shell-nozzle junctions etc.

While modelling the equipment apart from beam & shell/plate elements, solid elements and other type of elements or combination thereof may be used. The mathematical model should not be oversimplified nor over-discretised. If FEM is to be used, the model should adequately represent the dynamic and static characteristic of the equipment as realistically as practicable. The model should be able to predict functional performance as well as structural adequacy.

6.2 Qualification for Functional Operability

Qualification of SSCs can be demonstrated by analysis and/or testing for assessing their intended functional operability.

6.2.1 Functional Operability by Analysis

The qualification of rotating equipment viz., pumps, fans, blowers, motors etc. and reciprocating equipment viz., compressors, diesel generators, reciprocating pumps etc. may be performed by analysis to assess their functional operability.

The general steps involved in qualification of these equipment to meet the qualification requirements of functional operability are the same as in para 6.1.1. In addition, the displacements of the moving components shall be demonstrated to be less than the clearances/gaps between the moving and stationary components/parts viz., impeller-casing, stator-rotor etc. The alignment of equipment shaft & motor shaft shall also be demonstrated to be within the specified value. The reactions at the bearing location shall be shown to be less than the specified bearing capacity.

6.2.2 Functional Operability by Test

Qualification of various types of active equipment, valves, electrical and instrumentation items (panels, instruments and devices including reactor control and shutdown devices, batteries, transformer, switchgear, MCC etc.) can be performed by test to demonstrate their functional operability. In general, the seismic test shall be conducted by mounting the equipment/ component on a shake table. While a seismic motion is given to the shake table corresponding to the location of equipment/component, the equipment/ component shall be checked for its intended functional operability. During the test, the operating loads/conditions of the equipment/ component shall also be simulated adequately. The test should conservatively simulate the seismic motion at the equipment/ component mounting

location. The multidirectional nature of earthquake should be simulated. The list of the test facilities available in the country is given in Annexure-3.

6.2.3 Functional Operability by a Combination of Analysis and Test

Electrical & instrumentation panels, devices and other active equipment/ component can be qualified by a combination of analysis and test. The panel as a structure supporting the various active devices mounted at different locations in the panel can be analysed to calculate the seismic motion at the base of the active devices. The active devices then can be qualified on a shake table for the seismic motion determined at the base of these devices.

Moreover, it is not always practical to qualify all the equipment by testing. This may be because of the size of the equipment, its complexity, nature of equipment, etc. Large equipment, such as multibay equipment racks and consoles/panels etc., may be impractical to test at full scale due to limitations of the shake table. These type of equipment can be qualified by using combination of analysis and testing.

6.3 Qualification by Previous Seismic Analysis & Test Reports

If two or more equipment of same type, make, size, model and design are used in same or different nuclear power plant or different application and if any one of them is seismically qualified for one application requirement then other equipment can be accepted for different application provided following requirements are met:

1. It should be established that equipment design is similar to the reference equipment already qualified.
2. Equipment are mounted/ anchored with similar bolting/welding/EP/support arrangement.
3. Required response spectra of new application is same or lower than the previous application, when compared for same values of damping and OBE & SSE levels of earthquake as applicable.
4. If equipment is qualified by testing then Test Response spectra is enveloping the new RRS of the equipment to be qualified, for same values of damping in the frequency range of interest.
5. Adequate and sufficient documentation in terms of qualification report and justification as above are available to verify the qualification requirement.

6.4 Vendor's General Equipment Specifications (VGES)

For demonstrating structural integrity and pressure boundary integrity by analysis, the various loadings on the equipment as specified in the NPCIL's equipment specification shall also be specified in Vendor's General Equipment Specification (VGES). These loadings shall include design loads, loads during normal and upset

conditions (pressure, temperature, mechanical), number of cycles of transients experienced by the equipment, including OBE; loads during emergency and faulted conditions (pressure, mechanical), including SSE; test loads, etc., as specified in NPCIL's equipment specification. Above list is not complete, and as such, any additional loading coming on equipment due to specific design features shall also be specified in the VGES. The equipment is also required to be qualified for it's intended functional operability for the earthquake loading in combination with other operating loads as specified in NPCIL's technical specification and should form part of the VGES.

In order to meet the functional operability requirement of the equipment as brought out in this technical specification, various functions to be performed and functional parameters to be measured by the various devices and sub-devices in the equipment and which are to be monitored during the shake table test shall be brought out in the VGES. These include opening and closing time of valves, change in status of electrical contacts and relays; electrical contact and relay chattering; pressure, temperature, resistance, voltage, current settings etc as applicable.

7.0 SPECIFICATION FOR QUALIFICATION OF VALVES

This section covers the procedure for qualification of a general valve assembly including actuator, in terms of structural integrity, pressure boundary integrity and functional operability as brought out in NPCIL's equipment specification and in the VGES. The procedure shall be applicable to various power operated valves such as gate valve, globe valve, ball valve, butterfly valve, diaphragm valve, solenoid valve etc and relief valves. Manually operated valves and check valves are not required to be seismically qualified either by analysis or seismic test. However general requirements of design given in ASME Section-III, Division-1, Subsection-NB, NC and ND whichever is applicable shall be met for manually operated valves and check valves. For a specific valve, due to its specific design features if any additional technical requirements are to be met, same shall also be included in the VGES and shall also become part of the below mentioned qualification procedure.

In case of valves, general requirements of design are given in ASME Section-III, Division-1, Subsection-NB, NC and ND whichever is applicable. If any supports are used in the valve to support the valve component or the valve actuator from the valve body, those should be designed as per the general requirements given in ASME Section III, Division-1, Subsection NF. The material used for the valve assembly shall be as given in NPCIL's specification or as given in VGES. Structural integrity and pressure boundary integrity of the valve assembly shall be demonstrated by carrying out analysis, as applicable. For active valve assemblies, such as active power operated valve assemblies, and pressure relief valve assemblies, the functional operability of valve assembly shall be demonstrated by a test as applicable. The test covered in the specification pertain only to a seismic test. The list of shake table test facilities presently available in the country is given in Annexure-3.

The detailed procedure for qualification of a typical power operated valve assembly is given below:

7.1 Qualification for Structural Integrity and Pressure Boundary Integrity

7.1.1 Qualification by Analysis

Structural integrity and pressure boundary integrity of the valve assembly shall be assessed by performing an analysis. Simplified analysis may be performed based on static forces resulting from equivalent earthquake accelerations acting at the centres of gravity of the extended masses. Classical bending and direct stress equations, where free body diagrams determine a simple stress distribution that is in equilibrium with the applied loads, can be used (Ref-ASME Sec III NB-3524 & NB 3592.3 Earthquake) or FEM method as described below can be used.

7.1.1.1 **Finite Element Modeling**

Valve body, stem, bonnet, yoke, brackets for actuators, gear boxes and any other component may be modelled with appropriate material properties and section properties as calculated from the component detailed drawing using beam elements, shell elements, 3D brick element or combination thereof with justification of assumptions.

Connection between valve body-stem, valve body-yoke, valve yoke-stem, gearbox housing-stem, actuator shaft-gear, bearings, and any other connection specific to the valve may be appropriately modelled.

Concentrated masses of actuators, gearboxes, handwheel, disc of butterfly valve, limit switches or any other devices of the valve may be modelled as lumped mass at the C.G. location. The eccentricity of mass in the finite element model shall be taken into account. The bearings if any shall be modeled by suitable spring elements. The spring constants for bearings shall be used from authenticated document and shall be referred/attached with the report.

Valve ends should be modeled appropriately using boundary elements, spring element or fixed boundary condition.

Any other peculiar construction details of valve assembly may also be modelled appropriately using spring or mass or spring-mass system.

Finite element model of the valve assembly using above considerations shall adequately represent the realistic static/dynamic characteristics of the valve assembly. While modeling the valve assembly apart from beam elements, shell, plate, 3D brick element or combination thereof may also be used with justification. The Finite Element Model shall be forwarded to NPCIL both in soft and hard copies for review and approval before proceeding for further analysis. The assumptions made in the finite element idealization with justifications shall be brought out in the report and all the inputs used in the data preparation shall be from authenticated documents and shall be referred/attached with the report.

7.1.1.2 **Finite Element Analysis**

Using validated software, the valve assembly as modelled above shall be analysed to extract the natural frequencies of the valve. Two different sets of seismic qualification procedures exist depending upon whether the first natural frequency of the valve assembly is less than or greater than rigid/cutoff frequency as determined from the applicable spectra. When the first natural frequency is less than rigid/ cutoff frequency, the valve assembly is called as flexible assembly, whereas when the first natural frequency is greater than or equal to rigid/cutoff frequency it is

called as rigid assembly. All the valve assemblies shall be qualified for OBE alone or for OBE and SSE as applicable as given in NPCIL specification. Worst combinations of unsigned earthquake stresses with signed stresses to non seismic loads, shall be considered for qualification.

In case of rigid valve, the valve model shall be further analysed to evaluate seismic forces/stresses/displacements using equivalent static analysis method. In case of flexible valve assembly, either equivalent static analysis or response spectrum analysis may be performed.

In the equivalent static analysis method for rigid valves, force equivalent of 1.5 times the floor spectral peak acceleration shall be applied in 3 orthogonal directions at all mass points and the static analysis be carried out. In the equivalent static analysis method for flexible valves, force equivalent of 2.25 times (i.e. 1.5 x 1.5) the floor spectral peak acceleration shall be applied in 3 orthogonal directions at all mass points and the static analysis be carried out. The floor response spectra for OBE (2% damping) and SSE (3% damping) corresponding to the valve location, will be given by NPCIL as applicable.

For the response spectrum analysis to be performed on the flexible valve assembly, the applicable response spectra are the spectra at the valve mounting location on the piping system or equipment. These response spectra for OBE and SSE for 2% & 3% damping respectively will be derived by NPCIL & given by NPCIL corresponding to the valve location.

The response spectrum analysis shall include the addition of modal responses in each direction after accounting for closely spaced modes as per USNRC RG 1.92 and missing mass response as per NUREG 1061 vol. 4 (missing mass is the mass of the equipment which has not participated upto rigid/cutoff frequency) and three orthogonal directional responses combination by SRSS method.

If response spectra at the valve mounting locations are not available then floor response spectra accelerations scaled up by a factor of 1.5 shall be used (Ref-ASME QME 1-2012).

The valve assembly shall be analysed for various loads viz., design loads, loads during normal and upset conditions (pressure, temperature, mechanical, cycles, transients), including OBE; loads during emergency and faulted conditions (pressure, mechanical), including SSE; test loads; hydrodynamic, electromagnetic loads or any valve specific load, etc. as specified in the NPCIL's equipment specification and in the VGES.

If the valve actuator assembly is supported at multiple locations & subjected to different seismic motion, then the assembly shall be analysed for seismic anchor

movement (SAM). The SAM values at the support locations for OBE & SSE will be given by NPCIL as applicable.

The seismic displacements as obtained by seismic analysis shall be combined with displacements/deflections due to other loads and shall be checked for operational/allowable clearances specified at various component sub-assemblies viz. piston-cylinder of pneumatic actuator, stem-bush or steam-gland at the bush and gland location of the yoke, valve disk to valve seat deflections etc.

For fatigue analysis if applicable, fifty stress cycles corresponding to five numbers of OBEs (ten stress cycles per OBE) and ten stress cycles corresponding to one SSE event shall be accounted in addition to the stress cycles due to other loads as specified in the NPCIL's equipment specification and in the VGES.

7.1.2 **ASME Codal Qualification**

Load combinations to be adopted for ASME Class-1, 2 & 3 valves for design condition and various service levels are given in Annexure –1.

The combined stresses calculated in the valve assembly shall meet the relevant codal requirements viz. ASME Section-III, Division-1, Subsection-NB-3000, NC-3000, ND-3000 whichever is applicable.

The combined stresses in the bracket, supporting structure of actuator etc shall meet the requirements of ASME-III, Division-1, Subsection-NF-3000.

If there are any bearings, the load at the bearing location shall be less than the bearing load capacity.

The stresses in the weld connections if any shall be checked. The stresses may be checked as per NUREG CR-6241, IS 800, IS 456 or any other applicable code.

The seismic displacements as obtained by seismic analysis shall be combined with displacements/deflections due to other loads and shall be checked for operational/allowable clearances specified at critical locations of valve actuator assembly, if applicable.

7.2 **Qualification for Functional Operability**

7.2.1 Qualification by Analysis

The functional qualification of certain valves can be demonstrated by Analysis with prior approval of NPCIL. The seismic response as obtained by seismic analysis shall be combined with responses due to other loads and shall be checked for

operational/allowable values specified at various component sub-assemblies. For example, the functional operability of relief valves can be demonstrated by analysis, showing that valve disc does not lift up by seismic inertial force.
The functional qualification of large size valves viz. Main Steam Isolation Valve (MSIV) etc. is not possible to demonstrate by shake table test. In such cases for such large size valves, the functional operability can be checked by performing analysis by showing that the deflections and so the resultant clearance being less than allowable clearances i.e. between piston-cylinder of pneumatic actuator, stem-bush or steam-gland at the bush and gland location of the yoke, valve disk to valve seat deflections.

7.2.2 Qualification by Test

7.2.2.1 Determination of Natural Frequency

The first natural frequency or all modes below the cutoff frequency or rigid frequency of valve assembly may be determined by exploratory vibration test. Exploratory vibration test on a valve assembly may be conducted on a shake table, using resonance search test as per IEEE 344, with the modification that the vibration test shall be over a frequency range of 1 to 100 Hz or cutoff frequency as applicable. Natural frequency determination can also be done by Impact Hammer test, or any other justifiable method. The procedure for the Impact hammer test is given in Annexure-6.

The procedure covering the details of test method; mounting arrangements; test setup; test sequence; test equipment, instruments; measuring parameters; etc. shall be prepared as per the clauses given in this specification and shall be submitted to NPCIL for prior approval.

Exploratory vibration test Impact Hammer test shall then be conducted meeting the requirements of approved procedure.

7.2.2.2 Environmental Aging Test

Any environmental (temperature, pressure, humidity, plant operating vibration, irradiation) aging effects on the valve assembly, if specified in NPCIL's valve specification, shall be performed before conducting the equivalent static loading test or shake table test. The guidelines for these tests viz., normal thermal aging test, normal pressurization cycle test, normal radiation test, vibration aging test, Design Basis Event (DBE) environment test are given in Part-III of IEEE 382 (2006). If the valve is determined not to have significant aging mechanisms by virtue of periodic inservice surveillance, maintenance etc., then periodic surveillance, maintenance interval becomes qualified life, if applicable as per NPCIL specification or VGES. In view of the above, omission or partial fulfillment

of the environmental aging tests with justification shall be forwarded to NPCIL for approval.

7.2.2.3 **Qualification of Actuator**

Since valves are mostly rigid and are tested by equivalent static load test, whereas actuators see the earthquake motion at the valve top which is amplified by piping and support. Hence the valve actuators shall be separately qualified seismically as per the requirements of IEEE 382. However, the test frequency range should be from 1-100Hz in case of hard rock sites. In case, the actuator has already been seismically qualified by the actuator supplier, qualification report shall be submitted to NPCIL for approval.

7.2.2.4 **Qualification of Valve by Testing**

The valve assembly is required to be tested for demonstrating the functional operability by any one of the following methods:

1. Single frequency input on uniaxial shake table,
2. Multi frequency input on tri-axial shake table,
3. Static side load test.

For quick acting solenoid valves e.g. solenoid valves in SSS (Secondary Shutdown System) / SDS#2 (Shut Down System # 2) or Pilot Operated Valves in Shutdown system of BWRs, and critical valves that are required to perform during OBE and/or after SSE event or the valves important to reactor safety, housing flexible components in it e.g. springs etc they shall be shake table tested.

For other power actuated valves, static side load test may be conducted as per ASME QME 1-2012.

If the valve is required to be functional during OBE and SSE, only one test corresponding to SSE level loading need to be performed.

7.2.2.4.1 **Qualification using Single Frequency Inputs on Uniaxial Shake Table**

The tests on valve actuator assembly can be conducted on uniaxial shake table capable of giving horizontal and vertical motion, one at a time. The valve actuator assembly shall be mounted on the shake table. While a seismic motion is given to the table the valve assembly should be checked for its intended functional operability. As specified in the approved procedure, during the test, the operating loads on the valve assembly should also be simulated adequately. Single (Discrete) frequency tests using sinusoidal waveforms shall be used for frequencies from 1 Hz to 100 Hz or cutoff frequency as applicable. The test frequencies may be spaced

at 1/3 octave interval upto 50 Hz and at 1/6 octave interval beyond 50Hz, if required. The acceleration values shall be taken as 1.5 times of spectral peak acceleration of envelope of the floor response spectra of the floors on which valve mounted pipelines are supported. The floor response spectra of all three directions with 2 % damping for OBE and 3% damping for SSE shall be used. The acceleration value of OBE and SSE whichever is maximum shall be used as input motion. The test duration at each frequency shall be 30 second or more to verify the opening and closing of the valve assembly or for intended functional operability. The acceleration at low frequencies i.e below 4Hz shall be given upto the capability of the shake table. The test shall be conducted in two horizontal directions and one vertical direction.

If accelerations values are not available, then tests at 3.5g acceleration level as input can be permitted (Ref. Fig.1 of IEEE-382, 2006) with proper justification.

Typical procedure for uniaxial shake table test is given in Annexure-5.

The procedure for seismic qualification test of valve on uniaxial shake table covering the details of mounting arrangements, loadings, shake table description, test sequence etc. shall be prepared as per clauses given above/Annexure and as per IEEE 344 and shall be submitted to NPCIL for prior approval.

The seismic qualification test on shake table, for valve assembly shall then be performed at a test facility and shall meet the requirements of IEEE 344/IEC 60980 and/or approved procedure.

7.2.2.4.2 **Qualification using Multi Frequency Input on tri-axial Shake Table**

The valve actuator assembly shall be mounted on the shake table. While a seismic motion is given to the table the valve assembly should be checked for its intended functional operability. As specified in the approved procedure, during the test, the operating loads on the valve assembly should also be simulated adequately. The test should conservatively simulate the seismic event at the valve mounting location. The SSE and OBE required response spectra (RRS) at valve mounting location will be given by NPCIL. If response spectra at the valve mounting locations are not available, then floor response spectra accelerations scaled up by a factor of 1.5 times may be used (Ref-ASME QME 1-2012). The multidirectional nature of earthquake shall be accounted. In general, the shake table motion shall be such that it

i) produces a Test Response Spectra (TRS) that envelopes the Required Response Spectra (RRS).
ii) has a peak acceleration equal to or greater than RRS Zero Period Acceleration (ZPA).

iii) does not include frequency content above the RRS ZPA asymptote.
iv) has sufficient duration commensurate with strong motion part and fatigue inducing potential of the time history.

The procedure for seismic qualification test of valve on triaxial shake table covering the details of mounting arrangements, loadings, shake table description, test sequence etc. shall be prepared as per clauses given above/Annexure and as per IEEE 344 and shall be submitted to NPCIL for prior approval.

The seismic qualification test on shake table, for valve assembly shall then be performed at a test facility and shall meet the requirements of IEEE 344/IEC 60980 and/or approved procedure.

7.2.2.4.3 **Qualification using Static Side Load Test**

ASME QME 1-2012 permits the use of static side load test for power actuated valves.

Static side load testing is a seismic test intended to demonstrate the functional capability of the valve actuator assembly when subjected to loading that is representative of a specified seismic load qualification level.

The static side load test method for Power actuated valves are given in Annexure-4**.**

For static side load test, accelerations corresponding to 1.5 times the spectral peak acceleration of the floor response spectra corresponding to valve location in three orthogonal directions at 2 % damping for OBE and 3% damping for SSE shall be considered. Accelerations in three orthogonal directions shall be combined by SRSS method. Acceleration value thus obtained shall be further multiplied by following factors (Ref-ASME QME 1-2012).

1.1 (test margin) if the valve assembly is determined to be rigid, or
1.65 (amplification coefficient of 1.5 plus test margin) if the valve assembly is determined to be flexible, by carrying out analysis as per 7.1 or natural frequency determination test.

Typical procedure for Static side load test is given in Annexure-4.

The procedure for seismic qualification test of valve by Static side load test covering the details of mounting arrangements, loadings, test sequence etc. shall be prepared as per clauses given above/Annexure and as per IEEE 344 and shall be submitted to NPCIL for prior approval.

The seismic qualification by static side load test, for valve assembly shall then be performed at a shake table test facility and shall meet the requirements of IEEE 344/IEC 60980 and/or approved procedure.

7.3 Documentation

The valve assembly finite element model and the data giving details viz., nodal coordinates, element type used, element node relationship, material and section properties, lumped masses, rigid elements, and end release codes, details as to whether consistent mass matrix or lumped mass matrix, loads applied, boundary conditions etc. shall be submitted for prior approval of NPCIL in both soft and hard copies prior to taking up the analysis. The validation report of the software, describing the benchmark problem used to establish the dynamic analysis capabilities of the package along with the bench marking report shall also be submitted to NPCIL.

The qualification report shall be prepared covering the description of the finite element model, assumptions made in the modeling and their justification, input data with supporting reference documents, name and version of the software used for analysis and its validation, natural frequencies calculated, modal mass participation factors, missing mass correction calculations, equivalent static / response spectrum analysis results viz., stresses and displacements; combination of stresses for different service levels, compliance of stresses with codal requirements and displacements to be within the design clearances, results, conclusions stating the fulfillment of qualification requirements, etc. shall be submitted to NPCIL for approval.

The finite element model along with analysis input data files and results in hard and soft copies shall be submitted to NPCIL for records.

For the valve assembly qualified by testing (including impact hammer test), the test reports covering the approved test procedure, mounting methods, shake table details, test setup, test sequence, input motion and details of compliance with IEEE 344 and IEC 60980 etc. shall be prepared & submitted to NPCIL for approval & records.

The analysis/test reports shall be documented in the form such that the reports shall be self-explanatory and independently reviewable. Guidelines given in Clause-11 of IEEE 344 or Appendix-C of ASME section III, including the NPCIL VGES procedure are to be followed for the same.

8.0 SPECIFICATION FOR SEISMIC QUALIFICATION OF ELECTRICAL & INSTRUMENTATION ITEMS (PANELS, EQUIPMENT, INSTRUMENTS AND DEVICES)

This section covers the procedure for qualification of electrical and instrumentation items (panels, instruments, equipment and devices) in terms of structural integrity, pressure boundary integrity and functional operability as applicable, brought out in the respective NPCIL's equipment specification and in the VGES. This procedure shall be applicable to various panels such as instrumentation and electrical panels, standard electronic cabinet, control panels, panels used for A/c packages or switchgears, valve station racks, instrument racks, battery stands, instruments / devices / modules mounted on floor / walls / panels, etc. However, any additional functional requirement on account of specific design shall also be included in the below mentioned qualification procedure.

For the design of the panel as a structure, the general requirements of design are given in ASME Section III, Division-1, Subsection NF-3000 & IEEE 420. The material properties to be used for the equipment shall be as given in NPCIL's specification or as given in VGES. Structural integrity of the panel and pressure boundary integrity of any equipment mounted in the panel shall be demonstrated by carrying out an analysis and/or testing. Functional operability of the panel can be demonstrated by testing or by combination of analysis and testing. However, functional operability and structural integrity for the instrument and I&C devices shall be demonstrated by testing only wherever applicable. The test covered in this specification pertain only to seismic test. The list of recognized shake table test facilities presently available in the country is given in Annexure-3.

The detailed procedure for seismic qualification of a general panel assembly/ instruments/ equipment / devices is given below:

8.1 Qualification for Structural Integrity and Pressure Boundary Integrity

8.1.1 Qualification by Analysis

The structural integrity of the panel as a structure and instrumentation items requiring only structural integrity (e.g. orifice, venturi etc.) shall be assessed by analysis. The structural integrity and pressure boundary integrity of tanks, piping, tubing, heat exchangers etc. mounted on the panel can also be assessed by analysis.

The panel shall be analysed by finite element method. The various steps involved in finite element idealisation and the static & dynamic analyses of the panel are brought out below:

8.1.1.1 **Finite Element Modeling**

Major structural members of the panel may be modelled using beam elements with appropriate material and section properties calculated from detailed drawings of structural assembly. The plates used in the panel may be modelled as lumped mass or plate / shell element if required / justified.

Some of the panels may have heavy electrical components viz., blower, switch gear, transformers, coils, batteries, etc. and mechanical / instrumentation components viz., tanks, small heat exchangers, valves, transmitters, catchpots etc. Such components may be appropriately modeled using lumped mass at their CG locations with rigid link or spring element in the finite element model of the panel. The connection between heavy components and panel structure may be appropriately modelled with spring-mass system. For the components mounted on thin sheet metal of the panel, following may be adopted:

Light devices and various instruments (viz. relays, contactors, PCB's etc.) mounted on the plate (modules) may be modelled as lumped mass or combination of spring mass system with proper justification.

Cabling, tubing or any other connections connected with panel may be appropriately modelled by using spring/boundary elements. Similarly, the panel mounting/support arrangements may be appropriately modelled by using spring, boundary element or fixed boundary condition.

All the critical sections of panel, base plates, connections of instruments, mounting hardware of instruments, etc. shall be modelled adequately. The finite element model shall correctly represent the actual welding details viz. spot welds, line weld etc.

The finite element model using above considerations shall adequately represent the realistic dynamic/static characteristics of the panel assembly. While modelling the panel and the major mechanical and electrical components mounted on the panel like tanks, small heat exchangers, transformers, switchgears, etc., apart from beam, plate & shell elements, 3D brick element or combination thereof may also be used with proper justification. The finite element model prepared shall be forwarded to NPCIL both in soft and hard copies for review and approval before proceeding for further analysis. The assumptions made in the finite element idealization with proper justification shall be brought out in the report. All the inputs used in the data preparation shall be from authenticated document and shall be referred/attached with the report.

8.1.1.2 **Finite Element Analysis**

Using the validated software, the panel as modelled above shall be analysed using response spectrum analysis. The response spectrum analysis shall include the addition of modal responses in each direction after accounting for closely spaced modes as per USNRC RG 1.92 and missing mass response as per NUREG 1061 Vol. 4 (missing mass is the mass of the equipment which has not participated upto rigid frequency) the response upto rigid frequency and the missing mass response combined by SRSS and three orthogonal directional response combination by a SRSS method. The panel should be qualified for OBE alone or OBE and SSE as applicable. The floor response spectra at the mounting locations of panel for OBE (2% damping) and SSE (3% damping) will be supplied by NPCIL as applicable.

Some of the panels may have components like tubing, tanks, piping, coolers, blower, small heat exchangers like radiator, etc. The panels and such components shall be analysed for various loads viz. design loads, loads during normal and upset conditions (pressure, temperature, mechanical, cycles, transients), including OBE; loads during emergency and faulted conditions (pressure, mechanical), including SSE; test loads; hydrodynamic, electromagnetic loads, etc. as applicable and as specified in the NPCIL's equipment specification and in the VGES. Worst combinations of unsigned earthquake stresses with other signed stresses due to non seismic loads, shall be considered for qualification.

If the panel assembly is supported at multiple locations & subjected to different seismic motion, then the assembly shall be analysed for seismic anchor movement (SAM). The SAM values at the support locations for OBE & SSE will be given by NPCIL as applicable.

The seismic displacements as obtained by seismic analysis shall be combined with displacements/deflections due to other loads and shall be checked for operational/allowable clearances specified at various component sub-assemblies etc.

For fatigue analysis if applicable, fifty stress cycles corresponding to five numbers of OBEs (ten stress cycles per OBE) and ten stress cycles corresponding to one SSE event shall be accounted in addition to the stress cycles due to other loads as specified in the NPCIL's equipment specification and in the VGES.

8.1.2 **ASME Codal Qualification**

Load combinations to be adopted for ASME Class-1, 2 & 3 components (equipment, piping) and panel/component supports for design and service levels are given in Annexure-1.

The combined stresses in the components like tanks, piping, heat exchanger, etc. shall meet the requirements of ASME Section-III, Division-1, Subsection-NB-3000, NC-3000, ND-3000 whichever is applicable.

The combined stresses in panel/component support structural members shall meet the requirements of ASME Section-III, Division-1, Subsection-NF-3000.

The stresses in the base plate & weld connections if any shall be checked. The stresses may be checked as per NUREG CR-6241, IS 800, IS 456 or any other applicable code. The foundation bolts design shall be checked as per ACI-349.

If there are any bearings the load at the bearing location shall be less than the bearing load capacity.

The seismic displacements as obtained by seismic analysis shall be combined with displacements/deflections due to other loads and shall be checked for operational/allowable clearances specified at critical locations of the panel assembly, if applicable.

8.2 Qualification for Functional Operability

8.2.1 Qualification by Test

8.2.1.1 Environmental Aging Test

Before the shake table test of panel or the instrument/device/module on the panel, other environmental aging tests if specified viz. thermal, pressure, humidity, radiation, plant vibrations, OBE vibration shall be conducted in accordance with IEEE 323 and IEC 60780. The assessment of equipment aging effect is required to determine if aging has significant effect on intended functional operability of the devices in the panel. For example, electromechanical equipment shall be operated to simulate the expected mechanical wear and electrical contact degradation, contact pitting, etc. of the device to be tested. If the equipment is determined not to have significant aging mechanisms by virtue of periodic inservice surveillance, maintenance etc. then periodic surveillance, maintenance interval becomes qualified life. In view of the above, omission or partial fulfillment of the environmental aging tests with justification shall be forwarded to NPCIL for approval.

8.2.1.2 Qualification by Shake Table Test

The panel or the devices can be shake table tested by one of the two methods given below.

a) Full scale testing of a panel:

The functional operability of the panel including the devices/instruments mounted on the panel can be demonstrated by full scale testing of the panel on a shake table in accordance with IEEE 344 /IEC 60980. If the testing is done on a representative panel then, the panel shall be mounted with all the possible components, instruments, devices etc. at their respective locations to ensure maximum / optimum loading.

The panel shall be mounted on the shake table. While a seismic motion is given to the table, the instrument/devices in the panel should be checked for its intended functional operability and structural integrity as detailed in respective NPCIL equipment specification. To establish structural integrity of the panels, operating loads on the equipment should be simulated during the test adequately. The stresses at critical locations shall be monitored by mounting strain gauges and accelerometers, during the test. The locations for mounting strain gauge, accelerometer will be finalized in consultation with NPCIL engineers.

The test should conservatively simulate the seismic event at the equipment mounting location. The multidirectional nature of earthquake should be accounted. In general the shake table motion should be such that it

i) produces a Test Response Spectra (TRS) that envelopes the Required Response Spectra (RRS).
ii) has a peak acceleration equal to or greater than RRS Zero Period Acceleration (ZPA).
iii) does not include frequency content above the RRS ZPA asymptote.
iv) has sufficient duration commensurate with the strong motion part and fatigue inducing potential of time history.

In the panel testing, the RRS are the 5% damping Floor Response Spectra (FRS) of the floor on which the panel is mounted. The floor response spectra which is to be used for testing, for 5% damping for SSE and OBE will be given by NPCIL.

b) Testing of instruments devices mounted on the panel /support/rack, sections of multi-cabinet assemblies by combined analysis and test:

During analysis, if panel/support/rack is found to be rigid (i.e. first natural frequency greater than or equal to cutoff frequency) then the functional operability of the instrument/device/module mounted in the panel/support/rack can be demonstrated by testing individual instrument/device/module on shake table. In this case the floor response spectra are the Required Response Spectra (RRS) for testing.

If the panel/support/rack is found to be flexible (i.e. first natural frequency less than cutoff frequency. The functional operability of the instruments/devices/modules mounted in the panel can also be demonstrated by testing individual instruments/devices/modules on the shake table. In this case, response spectra at the base of instruments/devices/modules mounted in the panel are used as Required Response Spectra (RRS) for testing. These response spectra are obtained from time history analysis of the panel. The time history analysis of the panel shall be carried out using the same finite element model prepared as given in 8.1.1. Time history analysis shall be performed to calculate the time history and response spectra at the base of the instrument/device/module mounted in the panel. Any other method for generation of the RRS or accelerations at the base of the device in the panel can be used with proper justification. For example generic values of in-cabinet amplification (Table 6.2 of SQUG, DOE-GIP) can be used to arrive at the accelerations at the base of the devices from the floor response spectra. The intended functional operability of the instruments/devices/modules can be demonstrated by mounting them on a shake table and then perform the test in accordance with IEEE 344 / IEC 60980. In the device testing, response spectra at the base of the device on the panel are used as Required Response Spectra (RRS). If the RRS at the base of the devices are not available then, accelerations at the base of the devices derived from response spectrum analysis of the panel or other justifiable methods can be used for testing of devices. A sample test procedure for conducting seismic test on a typical instrument/ device is enclosed as Annexure-5.

For multi-cabinet assemblies like UPS, switchgear and MCC panels, cabinets containing 19” rack, few of the electrically and mechanically representative sections of multi-cabinet assembly can be seismically tested on shake table using appropriately increased RRS (usually more than 10%) accelerations and/or appropriate analytical justification for multi-cabinet assembly qualification as applicable.

The procedure for shake table test covering the mounting arrangement, pre-post intermediate inspection, monitoring parameters, input motion, shake table facility, environmental aging test, operational loads, acceptance criterion, etc. shall be prepared as per IEEE 344/ IEC 60980 and submitted to NPCIL for prior approval.

The shake table test shall then be conducted at a shake table test facility and shall meet the requirements of IEEE 344 / IEC 60980 or the approved procedure.

8.3 Documentation

The equipment finite element model and the data giving details viz., nodal coordinates, element type used, element node relationship, material and section properties, lumped masses, rigid elements, and release codes, details as to whether consistent mass matrix or lumped mass matrix, loads applied, boundary conditions etc. shall be submitted for prior approval of NPCIL in both soft and hard copies prior to taking up the analysis. The validation report of the software, describing the benchmark problem used to establish the dynamic analysis capabilities of the package along with the bench marking report shall also be submitted to NPCIL.

The qualification report shall be prepared covering the description of the finite element model, assumptions made in the modeling and their justification, input data with supporting reference documents, name and version of the software used for analysis and its validation, natural frequencies calculated, modal mass participation factors, missing mass correction calculations, equivalent static / response spectrum analysis results viz., stresses and displacements; combination of stresses for different service levels, compliance of stresses with codal requirements and displacements to be within the design clearances, results, conclusions stating the fulfillment of qualification requirements, etc. shall be submitted to NPCIL for approval.

The finite element model along with analysis input data files and results in hard and soft copies shall be submitted to NPCIL for records.

For the equipment qualified by testing, the test reports covering the approved test procedure, mounting methods, shake table details, test setup, test sequence, input motion and details of compliance with IEEE 344 and IEC 60980 etc. shall be prepared & submitted to NPCIL for approval & records.

The analysis/test reports shall be documented in the form such that the reports shall be self-explanatory and independently reviewable. Guidelines given in Clause-11 of IEEE 344, including the NPCIL VGES procedure are to be followed for the same.

9.0 SPECIFICATION FOR QUALIFICATION OF ROTATING AND RECIPROCATING EQUIPMENT

This section covers the procedure for qualification of rotating and reciprocating equipment in terms of structural integrity, pressure boundary integrity and functional operability as brought out in the NPCIL's equipment specification and in the VGES. The procedure shall be applicable to rotating equipment viz. pump-motor assembly, fan, blower etc. and reciprocating equipment viz. compressor, diesel generator, reciprocating pumps etc.

In case of pumps, general requirements of design are given in ASME Section-III, Division-1, Subsection-NB, NC and ND whichever is applicable. If any supports are used for the equipment, those should be designed as per the requirements given in ASME Section III, Division-1, Subsection NF. The material used for the qualification of the equipment shall be as given in NPCIL's specification or as given in VGES. Structural integrity, pressure boundary integrity and functional operability of the equipment shall be demonstrated by carrying out analysis. The functional operability of the equipment can also be demonstrated by a test. The tests covered in the specification pertain only to a seismic test. The list of shake table test facilities presently available in the country is given in Annexure-3.

Typical procedure for qualification of centrifugal pump-motor assembly (i.e. rotating equipment) is given below. Similar procedure shall be followed for qualification of all other rotating/reciprocating equipment in the scope of this specification. However, for specific equipment, due to its specific design features any additional specific functional requirement to be met shall also be included in the VGES and shall also be included in the below mentioned procedure.

9.1 Qualification for Structural Integrity and Pressure Boundary Integrity

9.1.1 Qualification by Analysis

The structural integrity and pressure boundary integrity of the centrifugal pump-motor assembly can be assessed by performing an analysis.

9.1.1.1 Finite Element Modeling

Pump casing, motor casing, stator, shaft and rotor, impeller, coupling, frame of motor and pump, bearings of motor, pump sealing arrangements, mounting base frame/structure and any other components may be modeled with appropriate section and material properties as calculated from/given in the component detailed drawings. These components may be modeled with beam/shell/plate/3 D brick elements or combination thereof so as to adequately represent the static/dynamic characteristics of the pump-motor assembly.

Motor casing, pump casing, shaft, supporting structure of motor and pump may be modeled with beam elements. Stator and rotor of motor, impeller of pump may be modeled as lumped mass/spring mass system at appropriate nodes. The bearings shall be modeled by suitable spring elements. Coupling may be modeled using spring elements/master-slave/rigid link element or with appropriate use of end release code. Sealing arrangement may also be modeled with appropriate spring mass system. The spring constants for bearings shall be used from authenticated document and shall be referred/attached with the report.

Extensions of a stationary component upto the rotating component may be modeled by appropriate rigid links.

Foundation bolts for base frame, bolts of motor casing with base frame, bolts of pump casing with base frame, coupling bolts if any and bolts of flanges may be appropriately modeled by using boundary elements.

Any other peculiar construction detail of pump-motor assembly may also be modeled appropriately by using mass and spring-mass system.

Finite element model constructed using above considerations shall adequately represent the realistic static/dynamic characteristics of the pump motor assembly. The model prepared both in soft and hard copies shall be forwarded to NPCIL for review and approval before proceeding for further analysis. The assumptions made in the finite element idealization with proper justification shall be brought out in the report. All the inputs used in the data preparation shall be from authenticated document and shall be referred/attached with the report.

9.1.1.2 **Finite Element Analysis**

Using validated software, the finite element model shall be analysed to extract the natural frequencies of the pump-motor assembly.

If the first natural frequency of support frame and pump casing & motor casing is above rigid/ cutoff frequency, then motor shaft, rotor of the motor and pump shaft & impeller model may be decoupled from motor support frame and pump-motor casings. The support frame and pump casing & motor casing shall be analysed using equivalent static analysis method. In the equivalent static analysis method, forces equivalent of 1.5 times floor ZPA may be applied simultaneously in the 3 orthogonal directions at all mass points and static analysis carried out.

The decoupled rotating-assembly shall be analysed by using either equivalent static analysis method or response spectrum analysis method. In the equivalent static analysis method, forces equivalent of 1.5 times floor spectral peak accelerations

may be applied simultaneously in the 3 orthogonal directions at all mass points and static analysis shall be carried out.

If the first natural frequency of the support frame and pump casing and motor casing is less than rigid/ cutoff frequency, then integral model of pump support, stationary components, rotating parts and other devices may be prepared and analysed by using either equivalent static analysis method or response spectrum analysis method. In the equivalent static analysis method, forces equivalent of 1.5 times floor spectral peak accelerations may be applied simultaneously in the 3 orthogonal directions at all mass points and static analysis carried out.

The response spectrum analysis shall include the addition of modal responses in each direction after accounting for closely spaced modes as per USNRC RG 1.92 and missing mass response as per NUREG 1061 vol. 4 (missing mass is the mass of the equipment which has not participated upto rigid/ cutoff frequency). The response upto rigid frequency and the missing mass response shall be combined by SRSS method and three orthogonal directional responses shall also be combined by SRSS method.

The pump-motor assembly shall be checked for their operating frequency & it should be away from the natural frequencies of building floor.

The pump-motor assembly shall be qualified for OBE alone or OBE and SSE as applicable. The applicable response spectra are the response spectra at equipment mounting location. OBE (2% damping) and SSE (3% damping) response spectra at the base of pump-motor assembly or floor will be given by NPCIL as applicable. Worst combinations of unsigned earthquake stresses with other signed stresses due to non seismic loads, shall be considered for qualification.

The pump shall be analysed for the loads experienced by it at the nozzle location from the connected piping. The pump shall be analysed for various loads viz. design loads, loads during normal and upset conditions (pressure, temperature, mechanical, cycles, transients), including OBE; loads during emergency and faulted conditions (pressure, mechanical), including SSE; test loads; hydrodynamic, electromagnetic loads, etc. as applicable and as specified in the NPCIL's specification and in the VGES.

If the pump motor assembly is supported at multiple locations & subjected to different seismic motion, then the assembly shall be analysed for seismic anchor movement (SAM). The SAM values at the support locations for OBE & SSE will be given by NPCIL as applicable.

The seismic displacements as obtained by seismic analysis shall be combined with displacements/deflections due to other loads and shall be checked for

operational/allowable clearances specified at various component sub-assemblies viz. impeller-casing, stator-rotor, coupling, attached piping/ducting/cabling etc.

For fatigue analysis if applicable, fifty stress cycles corresponding to five numbers of OBEs (ten stress cycles per OBE) and ten stress cycles corresponding to one event of SSE shall be accounted in addition to the stress cycles due to other loads as specified in the NPCIL's equipment specification and in the VGES.

9.1.2 **ASME Codal Qualification**

Load combinations to be adopted for ASME Class-1, 2 & 3 pumps and pump supports for design and service levels are given in Annexure-1.

The combined stresses in the individual components/elements shall meet the relevant codal requirements viz. ASME Section-III, Division-1, Subsection NB-3000, NC-3000 and ND-3000 whichever is applicable.

The combined stresses in the base frame/support shall meet the requirements of ASME Section-III, Division-1, Subsection-NF-3000.

The combined stresses in mounting bolts of pump casing to base frame between motor and base frame, coupling bolts, flanges connecting bolts shall meet the relevant codal requirement viz., ASME Section-III, Division-1, Subsection NB-3000, NC-3000, ND-3000 & NF-3000.

The combined stresses in the nozzle, as calculated using WRC-297/WRC-107 or any other justifiable method shall meet the requirements of ASME Section-III, Division-1, Subsection NB, NC and ND.

The stresses in the base plate & weld connections if any shall be checked. The stresses may be checked as per NUREG CR-6241, IS 800, IS 456 or any other applicable code. The foundation bolts shall be checked as per ACI-349.

If there are any bearings, the reaction at the bearing locations shall be less than the bearing load capacity.

The seismic displacements as obtained by seismic analysis shall be combined with displacements/deflections due to other loads and shall be checked for operational/allowable clearances specified at various component sub-assemblies viz. impeller-casing, stator-rotor, coupling, attached piping/ducting/cabling etc, if applicable.

9.2 Qualification for Functional Operability

9.2.1 Qualification by Analysis

The seismic displacements as obtained by seismic analysis shall be combined with displacements/deflections due to other loads and shall be checked for operational/allowable clearances specified at various component sub-assemblies viz. impeller-casing, stator-rotor, coupling, attached piping/ducting/cabling etc. The reactions coming at the bearing locations shall be less than bearing load capacity.

9.2.2 Qualification by Test

The functional operability of rotating and reciprocating equipment is generally demonstrated by analysis as brought out above. However, these equipment can as well be qualified for their functional operability by conducting a shake table test in accordance with IEEE 344 and IEC 60980.

The equipment shall be mounted on the shake table. While a seismic motion is given to the table, the equipment should be checked for its intended functional operability. During the test, the operating loads on the equipment should also be simulated adequately.

The test should conservatively simulate the seismic event at the equipment mounting location. The multidirectional nature of earthquake should be accounted. In general, the shake table motion should be such that it

i) produces a Test Response Spectra (TRS) that envelopes the Required Response Spectra (RRS).
ii) has a peak acceleration equal to or greater than RRS Zero Period Acceleration (ZPA).
iii) does not include frequency content above the RRS ZPA asymptote.
iv) has sufficient duration commensurate with strong motion part and fatigue inducing potential of time history.

In the equipment testing, the RRS are the floor response spectra (FRS) of the floor on which the equipment is mounted.

The procedure for shake table test covering the mounting arrangement, pre-post intermediate inspection, monitoring parameters, input motion, shake table facility, environmental aging test, operational loads, acceptance criterion, etc. shall be prepared as per IEEE 344/ IEC 60980 and submitted to NPCIL for prior approval.

The shake table test shall then be conducted at a shake table test facility and shall meet the requirements of IEEE 344 / IEC 60980 or the approved procedure.

9.3 Documentation

The equipment finite element model and the data giving details viz. nodal coordinates, element type used, element node relationship, material and section properties, lumped masses, rigid elements, and end release codes, details as to whether consistent mass matrix or lumped mass matrix, loads applied, boundary conditions etc. shall be submitted for prior approval of NPCIL in both soft and hard copies prior to taking up the analysis. The validation report of the software, describing the benchmark problem used to establish the dynamic analysis capabilities of the package along with the bench marking report shall also be submitted to NPCIL.

The qualification report shall be prepared covering the description of the finite element model, assumptions made in the modeling and their justification, input data with supporting reference documents, name and version of the software used for analysis and its validation, natural frequencies calculated, modal mass participation factors, missing mass correction calculations, equivalent static / response spectrum analysis results viz., stresses and displacements; combination of stresses for different service levels, compliance of stresses with codal requirements and displacements to be within the design clearances, results, conclusions stating the fulfillment of qualification requirements, etc. shall be submitted to NPCIL for approval.

The finite element model along with analysis input data files and results in hard and soft copies shall be submitted to NPCIL for records.

For the equipment qualified by testing, the test reports covering the approved test procedure, mounting methods, shake table details, test setup, test sequence, input motion and details of compliance with IEEE 344 and IEC 60980 etc. shall be prepared & submitted to NPCIL for approval & records.

The analysis/test reports shall be documented in the form such that the reports shall be self-explanatory and independently reviewable. Guidelines given in Clause-11 of IEEE 344 or Appendix-C of ASME section III, including the NPCIL VGES procedure are to be followed for the same.

10.0 SPECIFICATION FOR QUALIFICATION OF TANKS, VESSELS, HEAT EXCHANGERS AND THEIR SUPPORTS

This section covers the procedure for qualification of passive equipment like tanks, vessels, heat exchangers, supports, etc. in terms of structural integrity and pressure boundary integrity as brought in the NPCIL's equipment specification and in the VGES.

In case of tanks, vessels, pressure vessel and tubes of heat exchangers and supports general requirements of design are given in ASME Section-III, Division-1, Subsection-NB, NC, ND for safety class-1, 2 and 3 respectively and Subsection NF whichever is applicable. For safety class-4/NINS (Not Important to Nuclear Safety) tanks and vessels, the general requirements of design are given in ASME section VIII, Division-1 and Division-2 or applicable National design code/standard. For shell & tube heat exchanger, the general requirements of design are given in Mechanical standard TEMA class-C. The material used for the equipment shall be as given in NPCIL's specification or as given in VGES. Special attention is required to be given while analysing the nozzles on the tanks and vessels.

The procedure for seismic qualification of tanks, vessels, heat exchangers and their supports is given below. However, any additional specific functional requirement to be met for these passive equipment due to it's specific design features shall also be included in VGES and also in the procedure mentioned below:

10.1 Qualification of Structural Integrity and Pressure Boundary Integrity

10.1.1 Qualification by Analysis

The structural integrity and pressure boundary integrity of tanks, vessels, heat exchangers, supports etc. can be assessed by performing analysis.

The tank, vessel, heat exchangers (including plate type) and their supports shall be analysed by simplified method as given in ASCE 4-98 with prior approval of NPCIL or by finite element method as applicable. The various steps involved in finite element idealisation and the static and dynamic analysis of the tank, vessel, heat exchangers and their supports are brought out below.

10.1.1.1 Finite Element Modeling

The tank and vessel body may be modelled with beam, plate, shell, 3-D brick elements or combination thereof with proper justification.

The tank and vessel including the contained fluid & Heat exchangers internals viz. tube sheets, baffle plate, tube bundles, adsorber, sparger, tubing, etc. may be modelled appropriately to represent their dynamic/static characteristics.

The support structure of the tank may be modeled with beam/plate elements with appropriate section properties as obtained from detail drawing of supports.

The foundation bolts may be modeled with boundary elements.

All the other components of tanks and vessels viz. internal piping, nozzle and support, manholes etc. shall be taken into consideration while preparing the finite element model. Tangent and bend elements shall be used for modelling the internal piping if present.

The finite element model of the tank, vessel, heat exchangers (including plate type), and their supports shall adequately represent the realistic dynamic and static characteristics of the equipment. The model prepared both in soft and hard copies shall be forwarded to NPCIL for review and approval before proceeding for further analysis. The assumptions made in the finite element idealization with proper justification shall be brought out in the report. All the inputs used in the data preparation shall be from authenticated document, and shall be attached/referred in the report.

10.1.1.2 **Finite Element Analysis**

The model prepared based on above guidelines shall be analysed by response spectrum analysis using validated software. The response spectrum analysis shall include the addition of modal responses in each direction after accounting for closely spaced modes as per USNRC RG 1.92 and missing mass response as per NUREG 1061 vol. 4 (missing mass is the mass of the equipment which has not participated upto rigid/cutoff frequency) the response upto rigid/cutoff frequency and the missing mass response combined by SRSS and three orthogonal directional response combination by SRSS method.

The tank, vessel, heat exchangers and supports shall be qualified for applicable levels of earthquake viz. OBE alone or OBE and SSE as specified in NPCIL's specification and in the VGES. Worst combinations of unsigned earthquake stresses with other signed stresses due to non seismic loads, shall be considered for qualification.

The response spectra for SSE and OBE (as per applicable damping) at equipment foundation will be supplied by the NPCIL as applicable.

The applicable damping values as given in Appendix N, of ASME B &PV, Section III, Division 1, Appendices are given below :

	% critical damping	
	OBE	SSE
Equipment	2	3
Internal Piping.	5	5

The loads coming at the nozzle locations on the tank, vessel, Heat Exchanger due to piping reaction shall be used for design and analysis of tank, vessel, Heat Exchanger and their nozzles.

The equipment shall be analysed for various loads viz. design loads, loads during normal and upset conditions (pressure, temperature, mechanical, cycles, transients), including OBE; loads during emergency and faulted conditions (pressure, mechanical), including SSE; test loads, nozzle load due to connected piping etc as specified in NPCIL's equipment specification and in the VGES. The sloshing effect due to seismic excitation should also be accounted wherever applicable. The hydrostatic & hydrodynamic effects of contained fluid may be accounted as per TID-7024 if applicable.

If the tank, vessel, Heat Exchanger etc is supported at multiple locations & subjected to different seismic motion, then the assembly shall be analysed for seismic anchor movement (SAM). The SAM values at the support locations for OBE & SSE will be given by NPCIL as applicable.

For fatigue analysis if applicable, fifty stress cycles for five numbers of OBEs (ten stress cycles per OBE) and ten stress cycles for one SSE event shall be accounted in addition to the stress cycles due to other loads as specified in the NPCIL's equipment specification and in the VGES.

10.1.2 **ASME Codal Qualification**

Load combinations to be adopted for ASME Class-1, 2 & 3 tank, vessel & heat exchanger and internal piping and supports for design and various service levels are given in Annexure-1.

The combined stresses in tank, vessel & heat exchanger and internal piping shall meet the relevant codal requirements viz. ASME Section-III, Division-1, Subsection-NB-3000, NC-3000 or ND-3000 whichever is applicable.

The combined stresses in support structure etc. shall meet the requirements of ASME Section-III, Division-1, Subsection-NF-3000.

The combined stresses in the nozzle, as calculated using WRC-297/WRC-107 or any other justifiable method shall meet the requirements of ASME Section-III, Division-1, Subsection NB, NC and ND.

The stresses in the base plate and weld connections if any shall be checked. The stresses may be checked as per NUREG CR-6241, IS 800, IS 456 or any other applicable code. The foundation bolts shall be designed as per ACI 349/318.

If there are any bearings, the load at the bearing locations shall be ensured to be less than the bearing load capacity.

The seismic displacements as obtained by seismic analysis shall be combined with displacements/deflections due to other loads and shall be checked for operational/allowable clearances specified at various critical locations of tank, vessel, Heat Exchanger etc if applicable.

10.2 **Documentation**

The equipment finite element model and the data giving details viz. nodal coordinates, element type used, element node relationship, material and section properties, lumped masses, rigid elements, and release codes, details as to whether consistent mass matrix or lumped mass matrix, loads applied, boundary conditions etc. shall be submitted for prior approval of NPCIL in both soft and hard copies prior to taking up the analysis. The validation report of the software, describing the benchmark problem used to establish the dynamic analysis capabilities of the package along with the bench marking report shall also be submitted to NPCIL.

The qualification report shall be prepared covering the description of the finite element model, assumptions made in the modeling and their justification, input data with supporting reference documents, name and version of the software used for analysis and its validation, natural frequencies calculated, modal mass participation factors, missing mass correction calculations, equivalent static / response spectrum analysis results viz., stresses and displacements; combination of stresses for different service levels, compliance of stresses with codal requirements, qualification of nozzles & supports and displacements to be within the design clearances (if applicable), bearing reaction less than bearing capacity (if applicable) results, conclusions stating the fulfillment of qualification requirements, etc. shall be submitted to NPCIL for approval.

The finite element model along with analysis input data files and results in hard and soft copies shall be submitted to NPCIL for records.

The analysis reports shall be documented in the form such that the reports shall be self-explanatory and independently reviewable. Guidelines given in Appendix-C of

ASME section III, including the NPCIL VGES procedure are to be followed for the same.

ANNEXURE - 1

Load Combinations for Design Condition and Service Levels for Equipment & Supports

Plant Load Classification	Design/Service level	Load combination
Design	Design condition	Pressure, dead weight, sustained loads, temperature(1)
Normal	Service level A	Normal operating loads and transients (pressure, temperature, mechanical)
Upset	Service level B	Pressure, dead weight, sustained loads, upset condition transients (pressure, temperature(2), mechanical), including OBE(3)
Emergency	Service level C	Pressure, dead weight, sustained loads, temperature(1), emergency condition transients (pressure, mechanical), SSE (3),(4)
Faulted	Service level D	Pressure, dead weight, sustained loads, temperature(1), faulted condition transients (pressure, mechanical), pipe rupture loads, SSE (3)

Note No:

1) Temperature is used to determine allowable stress only

2) Thermal transients under Level C shall also be considered in Level B

3) OBE and SSE include both inertial and Seismic Anchor Movement (SAM)

4) SSE inertial & SAM can be considered in level-C service limits if specified, otherwise SSE inertial and SSE SAM are to be considered in level D only.

ANNEXURE-2

1.0 General Design Guidelines for Equipment

Following points should be taken into account to improve the resistance of equipment to an earthquake-induced vibration:

a) For the portions of the equipment with a certain degree of freedom in design, the position of the center of gravity should be made as low as possible, and the mounting should be as stable as possible.

b) In case when equipment with a lower safety class is closely located to equipment with a higher safety class, it is necessary to check the configuration plan to make sure that the damage to the equipment with a lower safety class due to earthquake does not affect the equipment with a higher safety class.

c) In addition, the seismic supports should be such that they do not cause difficulties in the maintenance and servicing of the machines/ equipment.

d) It is important to avoid, as far as practicable, resonance of equipment, piping, instrumentation and core internals at the frequency of the dominant modes of supporting structures. In most cases, stiffness can be increased to avoid resonance. In some cases, when systems are made stiffer, the effect of thermal stresses, other dynamic loads and differential motions of supporting points may become significant.

e) For S2 Level earthquake ground motion, equipment may enter the range of nonlinear/elasto-plastic behavior. In this case, it is necessary to make sure that the required ductility is present in the system, particularly in the Embedded Parts (EPs). The design of the embedded part (EP) of the support should be such that the failure in concrete is avoided. Therefore, the strength of the load path through concrete should be much more than the strength of the anchorage rod of the EP.

f) Particular attention should be paid to the possibility of collision between adjacent components, or between components and adjacent parts of a building, as a consequence of their dynamic displacement. It is also important to allow for flexibility of connections between such components, between components and building penetrations and underground connections to buildings, as well as between buildings.

2.0 General Design Guidelines for Valves

a) Valves with heavy operators should not be mounted on small lines (< 1" dia) or, valve, operator and the line should be well supported and anchored to the same support structure to avoid overstressing of adjacent piping.

b) Valve operator cantilever length (distance between centerline of pipe to the top of the operator) should not be too large.

c) The valve actuator and the yoke should not be independently braced to the structure unless the pipe is also braced to the same structure immediately adjacent to the valve. If the operator is independently supported from the valve and attached piping, it may act as a pipe support and attract considerable load through yoke and possibly fail or bind the shaft. If both the operator and the valve/pipe are restrained, and if they are both not tied to the same support structure, then differential motion may lead to high seismic loads.

3.0 General Design Guidelines for Panels and Devices

For components such as electrical and instrumentation panels, devices viz. relays, pushbuttons, switches, circuit breakers etc. seismic qualification by testing is the recommended method.

The active components of electrical and control and instrumentation systems get qualified by testing. If the panel/rack is not part of the test, it is essential that the panel/rack be checked for structural integrity by analysis. If the device is qualified for a 3.5 g flat spectrum, it is necessary to show that the acceleration at device location is less than 3.5 g. It has been observed that a significant cause of these systems failing to function properly during and after an earthquake, is lack of anchorage or inadequate anchorage. Analyses should be performed to compare the anchorage capacity to the demand imposed by the seismic loading. This capacity evaluation should extend down to the embedded parts and the concrete structure.

Following guidelines are provided to avoid failure of panels and devices:

a) Oversized washers or reinforcing plates are recommended for thin equipment bases. Lock washers are recommended where even lowlevel vibration exists.

b) There should be no gap at the bolt or stud anchor locations for equipment containing essential relays, since they have the potential for opening and closing due to the load reversals during earthquake. This may cause impact loading on the equipment leading to generation of high frequency vibrations and may result in chatter of essential relays mounted therein.

c) Lack of adequate stiffness in the anchorage raises two concerns. First, the natural frequency could be lowered into the resonance range. Second, it could cause lift up of the cabinet off the floor during an earthquake resulting in high frequency impact loading and chatter of relays. Such inadequate stiffness may arise due to use of thin frame members and clip angles in the construction of motor control centers, switchgear, and instrumentation and control cabinets. Stiff load paths with little eccentricity are preferable for anchorages.

d) Battery racks should have close-fitting, crush-resistant spacers between the cells, which fill about two-thirds of the vertical space between the cells, to avoid rocking and colliding during the earthquake causing malfunction and damage. The battery racks should also have end and side rails, which are close fitting against the cells (with shims, if needed) to avoid tipping the batteries or sliding off the rack.

e) Adjacent cabinets of motor control centers, switchgear, distribution panels, transformers which are close enough to impact each other should be bolted together to avoid unbolted cabinets responding out of phase to one another and impacting each other during an earthquake. The resulting high frequency vibration loadings could cause essential relays to chatter.

f) Cabinets for the above mentioned items should not have large size (> 150 mm wide and 300 mm high) cutouts in the lower half of the cabinet. The concern is that the shear load from the earthquake will not be able to be transferred through the shear walls to the anchorage. Alternatively, the cutouts should be adequately reinforced.

g) All doors and drawout panels should be secured by a latch or a fastener. The concern addressed is that the doors or drawout panels could open during an earthquake and repeatedly impact the housing, causing internal components such as relays and contactors to malfunction or chatter.

h) For floor-mounted units such as battery chargers and inverters, the transformer, which is the heaviest component of this equipment, should be positively anchored and mounted near the base of the cabinet.

i) For temperature sensors, the detrimental differential displacement between the mounting of the connection head and the mounting of the temperature sensor should not occur so as to prevent the wiring to be pulled out of the sensor.

4.0 General Design Guidelines for Active equipments

The guidelines provided for design of structures, systems and component (SSC) by analytical method provide assurance of structural integrity and pressure boundary integrity.

For active components, viz., valves, pumps, fans, blowers, motors, compressors, diesel generators; electrical; and instrumentation panels devices viz. relays, pushbuttons, switches, circuit breakers etc. apart from structural and pressure boundary integrity, an assurance is also required about the functionality of the equipment during and/or after earthquake. The performance of some 'active' equipment (e.g. pumps, valves and diesel generator sets) under earthquake conditions can be calculated with adequate confidence by analysis, when their potential failure modes can be identified and described in terms of stress, deformation (including clearances) or loads. Typically this would involve calculating the relative displacement between the members likely to rub against each other and showing existence of adequate clearance to justify its functionability. The integrity of shaft bearings should also be assessed for the seismic loads. This specific requirement should be a part of the component specifications. It should be understood that a high level of analytical sophistication requires a number of assumptions and produces at best only an indicator of seismic behavior. Therefore, it is recommended that test or experiment be conducted to validate such analytical results, particularly with regard to functionality of the equipment.

When functionality of typical equipment has been demonstrated by analytical or experimental means for an earthquake motion, similar equipment can be considered qualified.

For horizontal Pumps, fans and motor generators, the driver and the driven component should be connected by a rigid base or common skid to avoid differential displacement between the driver and the driven component, which could cause shaft misalignment.

For vertical pumps, the impeller shaft and casing should not be cantilevered for more than 6 m below the pump mounting flange. It should have a radial bearing at the bottom of the casing to support the impeller shaft. Otherwise, there is a possibility of misalignment and bearing damage due to excessive lateral loads, damage to the impeller due to excessive displacement and damage due to interfloor displacement on multi-floor supported pumps.

5.0 General Design Guidelines for tanks and vessels

As far as the pressure vessel itself is concerned, usually the plate thickness is controlled by the pressure (and not by seismic load) and the effect of the seismic force on the equipment is relatively small in comparison with the normal stress during operation. However, for the support structure, since the seismic force is dominant, appropriate strength check should be made considering the seismic force. It is also necessary to ensure enough stiffness for the support, particularly, in the design of the anchorage, where there is a likelihood of damage. It is of particular importance to ensure that base plates are sufficiently stiff to avoid prying effects and that anchor bolts are adequately tightened to avoid rocking effects, lowered frequencies, increased response levels, higher-than-design loads and increased risk of loosening, pull-out or fatigue. Over-designed or redundant bolts, pre-loaded on installation to the tensile force expected during a seismic event are therefore recommended.

All safety related mechanical equipment, such as tanks, vessels and heat exchangers, piping and supports must be qualified to demonstrate structural integrity and pressure boundary integrity when subjected to earthquake loads. Dynamic modal analysis using time history or floor response spectrum (floor response spectrum in this case) method is certainly the most accurate procedure, but equivalent static method is also acceptable.

For equipment such as (i) Vertical vessel with skirt support, (ii) Vertical vessel with leg support, and (iii) Horizontal vessel on two saddle type supports; an equivalent beam model can be constructed. The seismic response is predominantly associated with the first mode. Hence, it is sufficient to use spectral acceleration at the first frequency to calculate the equivalent static loads (equipment mass x spectral acceleration). A static analysis is then performed by applying this force to calculate the stresses in vessel as well as in supports. The equivalent static force together with the overturning moment acts on the anchorage system and should be designed to withstand them.

ANNEXURE-3

List of Shake Table Test facilities in India

S.No.	Shake Table Test facility	Size	Capacity	Frequency range (Hz)	Acceleration (g)
1.	ERDA, Vadodara	0.6m x 0.6m	150 Kg Uniaxial shaketable	1-50	3.5
2.	ECIL, Hyderabad	1m x 1m, 35 cm stroke length	100 Kg Uniaxial shaketable	1-50	3.5
3.	SERC, Chennai	4m x 4m, 4 vertical & 4 hori. Actuators	30 T Triaxial shaketable	0.1-50	1.0
		2m x 2m	5 T Uniaxial shaketable	5-50	3.0
		3m x 3m	10 T Triaxial shaketable	0.1-50	1.0
4.	CPRI, Bangalore	3m x 3m, 4 ver & 4 hor actuators	10 T Triaxial table	0.1-50	1.0
5.	IGCAR, Kalpakkam	3m x 3m, 4 ver & 4 hor actuators	10 T Triaxial table	0.1-50	1.0
6.	IIT Roorkee	3.5m x 3.5m, 2 ver & 1 hor actuator	20 T Biaxial shaketable	0.1-50	1.0
7.	IIT Kanpur	1.2m x 1.8m	4 T , Uniaxial shaketable	NA	NA
8.	IIT Guwahati	2.5m x 2.5m, stroke length=500mm, max horizontal acceleration = 2g	5 T, Uniaxial shaketable	NA	NA
9.	IIT Mumbai	1.2m x 1.2m	1 T, Uniaxial shaketable	NA	NA

Note:

1. Above details are for information and guidance only.
2. Other electrodynamic/hydraulic shake tables at test facilities like ERTL Labs, CWPRS Pune, ARAI Pune, FCRI Pallakkad Kerala and any other test facilities which can meet the test specification may be explored and shaketable specification may be forwarded to NPCIL for approval prior to actual seismic test on equipment.
3. NA: not available

ANNEXURE-4

Static side load test

1. Purpose

Static side load testing is a seismic test intended to demonstrate the functional capability of the combination of a QME-1 qualified valve and a QME-1 qualified actuator when subjected to loading that is representative of a specified seismic load qualification level.

2. Definition

Rigid Equipment: Equipment, structures, and components whose lowest natural frequency is greater than the frequency value at the start of the zero period acceleration (ZPA) or the cut-off frequency of the applicable response spectrum.

Essential-to-function parts/components: those parts or components of the assembly that are essential to cause, permit, or enable the assembly to perform the specified accident-condition function or whose failure could prevent the performance of this function.

3. GENERAL REQUIREMENTS

a). Static side load testing shall be performed on the QME-1 qualified valve assembly under the seismic load to which the valve assembly is to be qualified. The adequacy of qualification testing performed under this Code Case shall be evaluated where differential pressure cannot be maintained sufficiently to simulate the full range of design-basis conditions for which the valve/actuator assembly is being qualified.

b). The magnitude of the seismic loading is determined to simulate the effect of the specified triaxial acceleration g-levels for which the valve assembly is to be qualified. A single axial force concentrated at the center of gravity of the valve extended structure, and applied along the least rigid axis (unless a more critical axis can be determined) may simulate specific seismic g-loads. If desired, increased seismic g-levels may be used to extend the seismic qualification to similar constructions.

1. The first step in calculating the seismic test load force, Ft, is to convert the triaxial acceleration g-level components, acting on the valve assembly, into a single resultant axial acceleration g-level by using the

square-root-sum-of-squares (SRSS) method. If acceleration at the valve location is not available then 1.5 times the floor peak acceleration (corresponding to 2% for OBE and 3% for SSE) shall be used as the g-values. This single axial g-level is then multiplied by the weight of the valve assembly extended structure to obtain a qualification load force Fq. This qualification load force may need to be further adjusted to compensate for the effects of gravity on the test valve assembly, depending upon the orientation of the valve assembly during the test and minor adjustment of the location of the test load force to assure contact with a structural member. Regardless of the location, the load must still create an equivalent moment in the most highly stressed location of the extended structure.

2. The test load force, Ft, is determined to ensure adequate margin to account for any dimensional or material tolerance differences between the test valve assembly and any production valve assemblies. Unless a different factor is justified to account for material and dimensional tolerances, the following relationship should be used to determine the test load force:

$$Ft \geq (A)(Fq)$$

where:

Ft = test load force, lbf (N)
Fq = required qualification load force, lbf (N)
A = multiplication factor, dimensionless
= 1.10 (test margin) if the valve assembly is determined to be rigid, or
= 1.65 (amplification coefficient of 1.5 plus test margin) if the test valve assembly is determined to be flexible

c). Test Pressure, psig (kPag).

For Power Actuated Valve Assemblies as per QME-1, QV-7450, the test operating pressure shall be the design pressure rating, but no greater than the 100°F (38°C) cold-working pressure rating for the valve assembly being qualified. The test operating pressure shall be greater than that for which the test valve assembly is to be qualified by a factor equal to the ratio of the actual test bar yield strength of the tested body material divided by the specified minimum yield strength of the body material, but no greater than 1.5 times the 100°F (38°C) cold-working pressure rating.

d). Test Differential Pressure, psig (kPag). The test differential pressure shall be the pressure differential maintained across the valve disc during the opening stroke. The value of the differential test pressure shall be determined by valve/actuator margin analysis calculations. The test differential pressure is not considered a rating value for the actuator or valve, but creates a repeatable test condition for diagnostic data comparison.

e). All essential-to-function accessories shall be attached to the valve assembly to satisfy the rigidity requirements of QME-1, QV-7450(b). The essential-to-function accessories that have not been previously qualified in accordance with IEEE-344 as part of the actuator assembly shall be seismically qualified by test in accordance with the test section of IEEE-344 per QME-1, QV-7450(b).

f). Testing will be performed at normal room temperature, not to exceed 100°F (38°C).

5.0 TEST METHOD

5.1 Power Operated Valve Assemblies

a). The valve assembly shall be installed in a test fixture with suitable provision for imposing the static test load, and such that the valve assembly is mounted by its normal mounting points (usually the valve body ends). The valve mounting shall be sufficiently rigid to resist the applied seismic load and ensure that the load force remains essentially perpendicular to the centerline of the valve extended structure. The test load force, Ft, shall be applied as described in 4(b)(1) above.

b). The seismic functionality test shall be made starting with one full operating cycle utilizing normal motive power. With the valve fully open, the valve body is maintained at the designated test pressure (as defined in 4(c) above), and valve closure is initiated. Following valve closure, establish the test differential pressure (as defined in 4(d) above) in the specified flow direction (or in the most adverse direction for bidirectional valves). Valve opening is then initiated. Differential pressure need not be maintained after the test valve assembly is unseated. Thrust (and/or torque), diagnostic data and stroke time measurements in both directions are to be recorded to establish baseline measurements. For guidance, see QME-1, Section QV-G, "Guide to Section QV: Determination of Valve Assembly Performance Characteristics."

c). With the valve in the open position, test operating pressure (as defined in 4(c) above) shall be established in the valve, and (while pressure is maintained) the test load force, Ft, shall be applied as specified in 4(b)(2) above. Deflection measurements of the extended structure are to be recorded.

d). While maintaining the test load force, Ft, a seismic functionality test shall then be performed in accordance with 5.1(e), and 5.1(f) below.

e). Three full operating cycles shall be performed with the test valve depressurized and utilizing the maximum motive power for actuation. Data, similar to 5.1(b) above, shall be taken for comparison to the baseline measurements.

f). Three full operating cycles shall be performed utilizing minimum motive power. With the valve fully open, the valve is pressurized at the designated test pressure and valve closure shall be initiated and timed. Following valve closure, establish the test differential pressure in the specified flow direction (or in the most adverse direction for bidirectional valves). Valve opening is then initiated. Differential pressure need not be maintained after the test valve assembly is unseated. Data, similar to 5(b) above, shall be taken for comparison to the baseline measurements.

g). With the valve in the open position, remove the test load force, Ft, and record deflection measurements of the extended structure.

h). Repeating test 5.1(b) above, finish testing with one full operating cycle utilizing normal motive power. With the valve fully open, the valve body is maintained at the designated test pressure (as defined in 4(c) above) and valve closure is initiated. Following valve closure, establish the test differential pressure (as defined in 4(d) above) in the specified flow direction (or in the most adverse direction for bidirectional valves).Valve opening is then initiated. Differential pressure need not be maintained after the test valve assembly is unseated. Data, similar to 5.1(b) above, shall be taken for comparison to the baseline measurements.

ANNEXURE-5

Sample Seismic Test Procedure for Valve/Valve actuator/ Instrument/Device

a) **Mounting arrangement** :

Mount the Valve/Valve actuator/ Instrument/Device (here in after called as test sample) on the shake table with a suitable fixture, simulating the actual mounting condition in the plant, meeting the requirements specified in section 8.1.1 of IEEE-344. The mounting arrangement shall be proposed by the supplier for approval of NPCIL.

b) **Monitoring Requirements During Testing** :

Necessary arrangements shall be made to assess the functional operability of test sample as required, meeting the requirements specified in section 8.1.2 of IEEE-344 and NPCIL equipment technical specification. The detail scheme for the monitoring function shall be proposed by the supplier, subject to approval of NPCIL.

c) **Aging Requirements** :

Prior to the seismic test, the test sample shall be subjected to applicable environmental aging mechanisms, such as thermal aging, radiation aging etc., as mentioned in 8.2.1.1 of this specification and as detailed in the respective NPCIL equipment specifications according to the qualified life of test sample. However, vibrational aging and OBE seismic testing are not required to be done on the test sample as the SSE test accelerations are enveloping OBE accelerations as well as vibrational aging due to number of sinusoidal tests in all three directions separately each for 30 seconds during SSE test as mentioned below.

d) **Resonance Search Test:**

Sine sweep test (Resonant frequency search test) shall be conducted on the equipment, varying the frequency at the rate of 1 octave/minute from 1 Hz to 100 Hz or cutoff frequency as applicable (up sweep) and 100 Hz or cutoff frequency as applicable to 1 Hz (down sweep) maintaining acceleration at constant magnitude of 0.2g to determine the resonant frequencies of the equipment. Structural response in terms of acceleration and strains shall be monitored by mounting the accelerometers and strain gauges at the pre-identified locations on the equipment being tested. Sine sweep test can be conducted in both vertical and horizontal axes. Resonance frequencies in all the three axes shall be identified in the frequency range of 1.0 Hz to 100 Hz or cutoff frequency as applicable. The Resonant frequency search test parameters are shown in Table below:

1	Type of Motion	Sinusoidal sweep
2	Axis of Motion	X,Y & Z
3	Frequency range	1.0 to 100 Hz or cutoff frequency as applicable
4	Acceleration	0.2g
5	Sweep rate	1.0 Octave/minute

Based on the results of resonant search test, if no malfunction or no natural frequency is observed below 10 Hz then acceleration levels for single axis test can be lowered in low frequency range with prior approval from NPCIL. However, it should be ensured during resonant search test that devices are in energized condition and proper functional and response monitoring is ensured by suitable monitoring measures.

e) **Seismic Test Procedure (SSE Test)** :

i) **Motion** **:** Sinusoidal

ii) Frequently Range : 1 Hz to 100 Hz or cutoff frequency as applicable

iii) Test Frequencies : 1.0 Hz, 1.26 Hz, 1.59 Hz, 2.0 Hz, 2.52 Hz, 3.17 Hz, 4.0 Hz, 5.04 Hz, 6.35 Hz, 8.0 Hz, 10.08 Hz, 12.67 Hz, 16.0 Hz, 20.16 Hz, 25.0 Hz, 32.0 Hz, 40.31, 50.8 Hz, 57.02 Hz, 64 Hz, 71.84 Hz, 80.63 Hz, 90.51 Hz, 100 Hz.

iv) Peak acceleration : The peak acceleration at frequencies 1.0 Hz, 1.26 Hz, 1.59 Hz, 2.0 Hz, 2.52 Hz, 3.17 Hz shall be preferably between 1.0g and 3.5g or to the capability of shake table. However at these frequencies, excitation must be continued to be maintained to the capability of shake table. For and beyond 4 Hz the peak acceleration shall be 3.5 g as a minimum or to the capability of shake table. Beyond 50.0 Hz, the acceleration shall be maintained about 1.0g or to the capability of shake table.

v) Test duration : 30 Sec. at each test frequency

vi) Test axes : Test shall be carried out in 2 orthogonal horizontal axes and vertical axis (one axis at a time).

vii) The procedure for seismic qualification test of valve/valve actuator/instrument/device on shake table covering details of mounting arrangement, monitoring arrangement, shake table description, test sequence etc., shall be prepared as per the clauses given in applicable NPCIL equipment technical specification and/or IEEE-344 and shall be submitted to NPCIL for prior approval.

viii) The accelerations calculated at location of mounting of devices in stands, racks, cabinets, panels or line mounted devices, should be shown to be less than test accelerations by carrying out analysis of stands/racks/panels/ cabinets/piping either by vendor or NPCIL as per applicable scope in tender specification.

ix) The seismic qualification test on shake table shall then be performed at the test facility and shall meet the requirements of IEEE-344 and/or NPCIL approved test procedure for seismic qualification of respective valve/valve actuator /instrument/device.

f) **Test Acceptance Criteria** :

The test sample shall meet the performance requirements during and after completion of the tests as specified in applicable NPCIL equipment technical specification/NPCIL approved test procedures.

g) **Test Report** :

The external laboratory conducting this test shall issue an approved test report consisting mainly of the following:

i) Copy of approved seismic qualification test procedure.

ii) Description of test sample along with its mounting and monitoring procedure

iii) Specification of test facility

iv) Mounting arrangement with photograph

v) Video recording in the form of DVD/pen drive of the complete shake table testing.

vi) Performance results of the test sample.

ANNEXURE-6

Impact Hammer Test for Frequency Determination of Valves

Impact hammer test shall be used for estimation of modal frequencies of the valves. The test will require impact hammers instrumented with a force transducer to measure the impact force, response measuring transducers (accelerometers) to measure the response caused by the known impact force, signal conditioners to condition the signal for the required frequency band and amplification, two channel signal analyser for signal analysis; and for computing frequency response function and coherence function. The model frequencies shall be estimated by appropriate analytical curve fitting method.

The particular characteristics of each element of the test are described below:

1. **Impact Hammer:** The impact hammer shall have a built in force transducer. Two important characteristics of impact hammer are its weight and tip hardness. Appropriate range hammer with selectable tip (soft, medium and hard) shall be used. The force transducer shall be integrally fixed on the hammer for impact force measurement.

2. **Response Transducer (accelerometers)**: Transducer shall be used for measurement of response at atleast two locations on the valve body. Sensor sensitivity shall be high enough to get repeatable signal above background noise.

3. **Signal Conditioning Units**: The units shall be suitable for low signal-to-noise ratio (40dB) and must be able to detect over load in the response signal.

4. **Analysis System**: Two-channel dynamic signal analyser shall be used. The analyser shall have zoom transform capability, appropriate window functions for impulse input signal and decaying response signals, and analytical curve fitting capability to extract modal properties.

Measurement Procedure

1. The valve assembly should be mounted in the rigid flange fixture. This fixture should be anchored to the anchor bolts embedded in rigid heavy mass concrete platform. The machinery noise in the shop should be minimal.

2. Frequency Response Measurement (FRF) shall be made at many locations on the valve body to identify major resonances. Use impact hammer of appropriate weight and tip hardness. Determine two best locations along each axis for mounting response accelerometer either by a strong magnet or by adhesive.

3. Check the repeatability of FRF Test. Preload the valve body (if required) to minimize non-linearities caused by gaps and clearances. Confirm low non-linearity effect on the response signal by coherence measurement.

4. Ensure that input signal is not zero in the frequency band of interest.

5. Monitor input force signal and apply appropriate window function. Reject poor measurement. Ensure input auto spectrum.

6. Monitor response signals and apply exponential decay window. Reject poor measurement and overload.

7. Determine FRF from the ratio of Cross Spectrum to Power Spectrum of input signal. Average (at least 24) and process the signal to minimize bias error in the estimation of the Cross-Spectrum. Estimate the coherence function to monitor the quality of FRF measurement.

8. Display FRF as magnitude versus frequency in logarithmic scale. Display phase versus frequency in linear scale.

9. Estimate modal parameter (if specified) by fitting an analytical curve on the FRF function. Ensure reasonable fit for good estimation of modal properties.

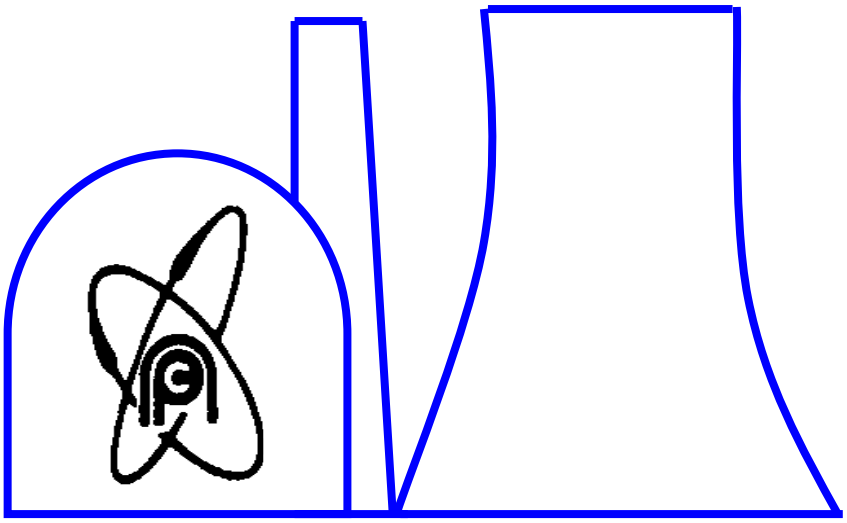
10. Perform zoom analysis around closely spaced modal frequency (Resolution 10:1).

11. Determine the phase between two measurement locations (along the axis) at the identified natural frequencies.

12. Include one set of prints of input auto spectrum, FRF and coherence function, phase angle etc. for each direction of test in the report.

Directorate of Quality Assurance

NDE PROCEDURES



PROCEDURE FOR VISUAL TESTING (VT) & MEASUREMENT INSPECTION (MI) OF STRUCTURES, SYSTEMS AND COMPONENTS (SSCs) OF NPPs DURING PERIODIC INSPECTION INCLUDING PSI & ISI

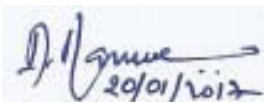
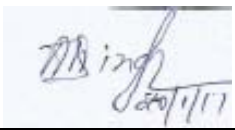
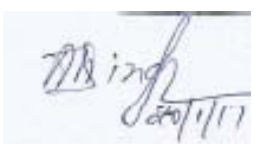
January 2017

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

SPECIFICATION NO.PP-P-00001 REV.NO.0

TITLE :	**PROCEDURE FOR VISUAL TESTING (VT) & MEASUREMENT INSPECTION (MI) OF STRUCTURES, SYSTEMS AND COMPONENTS (SSCs) OF NPPs DURING PERIODIC INSPECTION INCLUDING PSI & ISI**

REVISION NO.	**0**		
DATE OF ISSUE (Month/Year)	**January 2017**		
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	NAME	SIGNATURE	DATE
PREPARED BY	**A.Ramu**		**January 2017**
REVIEWED BY	**A.K.Singh**		**January 2017**
APPROVED BY	**A.K.Singh**		**January 2017**

REVISION CONTROL SHEET

PROCEDURE NO. : PP-P-00001

Revision. No.	Description of Revision	Revised by	Reviewed by	Approved by
0	New procedure prepared	---	---	---

1.0 PURPOSE:

1.1 This procedure describes the requirements of Visual Testing (VT) and Measurement Inspection (MI) of structures, systems and components during Periodic Inspection including Pre-Service Inspection (PSI)/In-Service Inspection (ISI) and examination techniques to be followed.

1.2 This procedure is also applicable for those SSCs which are not covered in PSI/ISI document of operating stations and projects. In addition, this procedure describes the qualification requirements (Performance Demonstration) of Remote visual inspection systems.

1.3 This procedure is prepared in line with the requirements of applicable codes and standards of PHWR/LWR (BWR), latest edition. Procedures also covers the technique sheet and format of record to be followed as part of documentation of examination and test results.

1.4 This procedure is also meant for Visual examination of Systems and Components that are subjected to pressure testing by Hydrostatic/Pneumatic testing.

2.0 SCOPE:

2.1 The inspection scope includes visual and measurement inspection (wherever applicable) using either direct and remote visual techniques applicable for Structures, Systems and components as covered in the respective station and projects PSI/ISI document as well as other SSCs which are not covered under these.

2.2 The inspection scope includes the condition of those surfaces that affects intended performance of SSCs by various degradation mechanisms. The degradations are (a) General Corrosion (b) Erosion-Corrosion (c) Flow Accelerated Corrosion (d) Micro-Bial Influential Corrosion (MIC) (e) Fretting corrosion (to name a few).

2.3 Visual Examination may need to be supplemented with other NDE methods (such as Ultrasonic Thickness gauging, Liquid Penetrant Examination etc.,) to ascertain the extent of degradation that could impair the functionality of SSCs for continued service.

2.4 Visual & Measurement inspection of SSCs also includes the dimensional verification as per approved drawings and documents, wherever applicable.

2.5 The scope is applicable for under water SSCs for its integrity checks using remote visual inspection techniques. This includes qualification of Visual and measurement inspection system prior to and after completion of actual examination.

2.6 The scope of Visual Examination is applicable to the pressure boundary of those SSCs under Hydrostatic/Pneumatic testing, as per the governing documents.

Specific visual examination procedures required for every type of examination because there are many applications where visual examinations are required. Some examples of these applications include non-destructive examinations, leak testing, in-service examinations and fabrication procedures.

3.0 GENERAL REQUIREMENTS:

The following requirements are applicable for any Visual Examination of Structures, Systems and Components (SSCs) covered under this procedure. Visual examinations are classified based on the type of discontinuities, deficiencies and evidences of leakage that are being observed by using visual inspection techniques. These requirements are specified in applicable construction codes and have been mentioned in the station governing documents.

3.1 VISUAL EXAMINATION METHODS:

3.1.1 VT-1 Examination:

VT-1 examination is conducted to detect discontinuities and imperfections on the surface of components, including such conditions as cracks, wear, corrosion, or erosion.

The procedure for VT-1 can be demonstrated with the capability of resolving the illumination, distance requirements, characters for demonstration requirements during the examination is given below.

(a) Minimum Illumination : 50fc (550Lux)

(b) Maximum Direct examaintion distance : 2ft. (600mm)

(c) Maximum height for Procedure demonstration characters : 0.044in.(1.1mm)

Remote visual examaintion can be substituted for VT-1 examination however, performance demonstration shall be met as indicated above. In addition, the

remote visual examaintion system shall be capable of distinguishing & differentiating between the colors applicable to the component examaintion being conducted.

3.1.2 VT-2 Examination:

VT-2 examination is conducted to detect evidence of leakage from pressure-retaining components, as required during the conduct of system pressure test.

No illumination, distance and illumination requirements are applicable for VT-2.

3.1.3 VT-3 Examination:

VT3 examination is conducted to determine the general mechanical and structural condition of components and their supports by verifying parameters such as clearances, settings, and physical displacements; and to detect discontinuities and imperfections, such as loss of integrity at bolted or welded connections, loose or missing parts, debris, corrosion, wear, or erosion.

VT-3 includes examination for conditions that could affect operability or functional adequacy of constant load and spring-type supports.

The procedure for VT-3 can be demonstrated with the capability of resolving the illumination, distance requirements, characters for demonstration requirements during the examination is given below.

(a) Minimum Illumination : 50fc (550Lux)

(b) Maximum Direct examaintion distance : Not applicable

(c) Maximum height for Procedure demonstration characters : 0.105in.(2.7mm)

Remote visual examaintion can be substituted for VT-3 examination however, performance demonstration shall be met as indicated above. In addition, the remote visual examination system shall be capable of distinguishing & differentiating between the colors applicable to the component examaintion being conducted.

3.2 Procedure Demonstration:

If the procedure is qualified once as indicated below then the reference of qualification need to be documented which is considered as adequate.

(a) In general, Visual Examination procedure shall be **demonstrated for its resolution** which a fine line of ***1/32" (0.8mm)*** or less width, an artificial imperfection or a simulated condition, located on the surface or a similar surface to that to be examined, may be considered as a method for procedure demonstration. This can be achieved by placing a stainless steel wires of varying sizes based on criticality of component (Class-1, Class-2 & Class-3) on a plate/round bar/tube of either CS/SS/Zircalloy as applicable.

(b) The resolution demonstration is applicable for both Direct Visual and Remote Visual examaintion techniques.

(c) For Direct Visual examination, inspection personnel's physical requirement is required to be demonstrated through annual vision acuity tests as indicated below.

(d) For Remote Visual examination, the inspection systems/visual aids being used shall demonstrate such that the minimum resolution is achieved as indicated above.

3.3 Personnel Qualification requirements:

Personnel performing Visual examination shall be qualified and certified in Visual Testing (Level-I/II) either from ISNT/ASNT.

3.4 Physical Requirements:

Visual examination personnel shall have an annual vision test to assure natural or corrected near distance acuity such that they are capable of reading standard **J-1 letters** on standard Jaeger test type charts for near vision. Equivalent near vision tests are acceptable.

3.5 Documents:

The following documents are required to be made available prior to performing VMI of SSCs.

(a) Approved drawings and data sheets, wherever applicable.

(b) Documents related to repair/replacement.

3.6 Surface condition of SSCs under Visual and Dimensional Inspection:

Visual examination is generally used to determine the surface condition of the part, therefore, the conditioning of the surface is essential to perform meaningful examination.

(a) For a new manufactured component, the surface finish requirements shall be as per the approved assembly/component drawing(s). This requirement is applicable during Pre-Service Inspection (PSI) of SSCs.

(b) For those SSCs which are to be examined during the service shall be ensured that the surfaces are free from loose rust, corrosion products, oil and grease that may mask the relevant indications.

3.7 Radiation protection requirements (at operating plants):

The inspection personnel associated with Visual and Measurement Inspection shall understand the radiation protection rules and guidelines in effect on the plant site with respective to protective clothing and follow instructions regarding radiation protection as recommended by Station Health Physics Unit.

3.8 Equipment (s):

3.8.1 Equipment used for visual examination techniques, for example, direct, remote shall have the capabilities which include, but are not limited to viewing, magnifying, identifying, measuring, and/or recording observations.

3.8.2 The equipments used during direct visual and measurement inspection are (a) Magnifying glass and Bench Magnifiers (Wherever applicable).

3.8.3 The equipments used for indirect/remote visual and measurement inspection are (a) Boroscopes (b) Fibroscopes (c) remotely operated PTZ cameras (d) radiation tolerant cameras for under water applications in radiation areas

4.0 VISUAL EXAMINATION – TECHNIQUES:

Visual Examination is used to determine (a) Surface condition (b) Alignment of mating surfaces or shape (c) missing and loose parts and (d) evidence of leakage from the pressure boundaries. In order to identify these, two techniques are used and these are (a) Direct Visual Examaintion and (b) Remote Visual Examination.

If the SSCs is having the accessibility, the same shall be examined with direct visual examination technique with/without using visual aids.

4.1 Direct Visual Examination:

4.1.1 Direct visual examination is usually be made when access is sufficient to place the eye within 24 in. (600 mm) of the surface to be examined and at an angle not less than 30^0 to the surface to be examined. ***The view angle requirement/ limitation is applicable only to direct visual examaintion technique.***

4.1.2 Mirrors may be used to improve the angle of vision, and aids such as a magnifying lens may be used to assist examinations.

4.1.3 Illumination (natural or supplemental white light) of the examination surface is required for the specific part, component, vessel, or section thereof being examined.

4.1.4 The minimum light intensity shall be 100 fc (1000 lx), (This is applicable for machined components during the manufacturing) however it may vary depending upon the type of degradation is being looked for.

4.1.5 The light intensity, natural or supplemental white light source, shall be measured with a white light meter prior to the examination or a verified light source shall be used.

4.1.6 Verification of light sources is required to be demonstrated only one time, documented, and maintained.

4.2 Remote Visual Examination:

4.2.1 Remote visual examination can be substituted for direct visual examination provided that the following requirements are satisfied.

4.2.2 Visual aids such as (a) mirrors (b) telescopes (c) borescopes (d) fiberscopes (e) cameras (f) other suitable instruments can be used to assess the condition of SSCs as per the accessibility.

4.2.3 The visual examination system resolution capability shall be qualified with the combination of visual aids along with the illumination.

4.2.4 In case of underwater visual examination system, the resolution capability of the system shall be qualified with the combination of visual aids (underwater camera) and light illumination using SS wires placed on similar surfaces (underwater) in the form of a grid. The size of the wires shall be selected based on the extent of degradation expected.

5.0 APPLICABILITY OF VISUAL AND MEASUREMENT INSPECTION:

Based on the design and construction code, the requirements of visual examination and measurement inspection (as applicable) are specified at various stages. These are during (a) the Pre-Service Inspection and (b) the In-Service Inspection (ISI).

The list of components that requires visual examination and dimensional measurement is given in the respective tables of station's PSI/ISI document.

6.0 VISUAL EXAMINATION - PROCEDURE:

6.1 Identify the part of SSCs to be examined as per the schedule of inspection document.

6.2 Check the technique sheet applicable for the inspection category (VT-1/VT-2/VT-3/Dimensional & Measurement Inspection).

6.3 Perform the visual inspection equipment qualification for procedure demonstration as mentioned above.

6.4 Perform the applicable inspection using the mentioned visual aids under the required illumination levels, as demonstrated.

6.5 Record all the observations in the **technique-cum-Observations data sheet** indicated in **ANNEXURE-I**.

7.0 EVALUATION OF EXAMINATION AND TEST RESULTS:

The visual examination as performed as per the checklist and the observations made there-in shall be reviewed and evaluated as per the acceptance criteria indicated as per the governing document(s) as indicated below.

8.0 ACCEPTANCE STANDARDS:

The acceptance standard for Visual Examination methods is as given below:

8.1 Visual Examination (VT-1):

The indications that show a change has occurred since the previous inspection shall be considered as acceptable, provided that

(a) The integrity of the system or component is within the specified design of the system or component ; and

(b) The predicted deterioration will not seriously reduce the integrity of the component before the next periodic inspection.

The inspection records shall state clearly the nature and extent of any change since the previous inspection.

8.2 Visual Examination (VT-2):

The structure, system and component is acceptable when there is no evidence of leakage is observed from the pressure boundary when checked during the pressure test (hydrostatic test/system leakage test).

8.3 Visual Examination (VT-3):

The structure, system and component is acceptable when examined for general mechanical and structural condition of components and their supports and the verifying parameters are within the acceptable limits (such as clearances, settings, and physical displacements) and no discontinuities and imperfections, such as loss of integrity at bolted or welded connections, loose or missing parts, debris, corrosion, wear, or erosion has been observed.

9.0 REFERENCE/APPLICABLE DOCUMENTS:

(a) CAN/CSA 285.4-14"Periodic Inspection of CANDU Nuclear Power Plant Components.
(b) ASME B&PV Code, Section-XI, 2015 Edition "Rules for In-Service Inspection of Nuclear Power Plant Components".
(c) ASME B&PV Code, Section-V, 2015 Edition "Non-Destructive Examination".
(d) PSI/ISI Documents (approved) of operating stations and projects.

ANNEXURE-I

	NUCLEAR POWER CORPORATION OF INDIA LIMITED (A Govt. of India Enterprise) QUALITY ASSURANCE DIRECTORATE	Technique sheet no.: **VMI/001** Revision no.: **0** Date : 20.01.20107

VISUAL TESTING AND MEASUREMENT INSPECTION TECHNIQUE-CUM-OBSERVATIONS DATA SHEET FOR PSI/ISI & OTHER SURVIELANCE

Name of structures, systems & components (SSCs)		
1.	Weld joint no. (Joint Number/Size/Wall thk.)	
2.	Component Identification: VESSELS/HX./PIPING/PUMPS/ VALVES/ SUPPORTS/FASTENERS/PRESSURE BOUNDARY	
3.	Material of Construction:	
4.	Surface Condition of SSCs:	
5.	Methods/tools used for surface preparation	
6.	Basis for Inspection:	PSI/ISI Document
7.	Work Procedure No.:	
8.	Reference Test Procedure No.:	
9.	Procedure Demonstration ref. doc.no.:	
10.	Reference Standards/Code for Quality Evaluation	ASME SECTION-XI & CAN/CSA/285.4-14
11.	Visual Examination Category (VT-1/VT-2/VT-3/DIMENSIONAL INSPECTION)	
12.	Inspection technique (DIRECT/REMOTE VISUAL)	
13.	Specify the location of SSCs (Open to the Surface/Under water)	
14.	Test Equipment /Visual Aids used	
15.	Test Equipments used for Measurement Inspection:	
16.	Testing Conditions (Light Intensity –Lux.)	
17.	Lighting Equipment used:	

	NUCLEAR POWER CORPORATION OF INDIA LIMITED (A Govt. of India Enterprise) QUALITY ASSURANCE DIRECTORATE	Technique sheet no.: **VMI/001** Revision no.: **0** Date : 20.01.20107

VISUAL TESTING AND MEASUREMENT INSPECTION TECHNIQUE-CUM-OBSERVATIONS DATA SHEET FOR PSI/ISI & OTHER SURVIELANCE

18.	Visual Examination Observations (indicate the condition of SSC as compared to the previous inspection observations)
.	
19.	Dimensional Measurement Inspection Observations(indicate the condition of SSC as compared to the previous inspection observations):
20.	**Acceptance criteria (CAN/CSA 285.4-14)**:

VT-1 & VT-3: *The indications that show a change has occurred since the previous inspection shall be considered as acceptable, provided that (a) The integrity of the system or component is within the specified design of the system or component; and (b) The predicted deterioration will not seriously reduce the integrity of the component before the next periodic inspection. The inspection records shall state clearly the nature and extent of any change since the previous inspection.* **VT-2:** *There shall not be any evidence of leakage from the system pressure boundary.*

21.	**Acceptance criteria (ASME B&PV Code, SECTION-XI, 2015 Edition)**: For VT-1 & VT-3 wherever applicable	

IWB-3515: Standards for Examination Category B-G-1, Pressure-Retaining Bolting Greater Than 2 in. (50 mm) in dia.
IWB-3517: Standards for Examination Category B-G-1, Pressure-Retaining Bolting Greater Than 2 in. (50 mm) in Diameter, and Examination Category B-G-2, Pressure-Retaining Bolting 2 in. (50 mm) and Less in Diameter
IWB-3519: Standards for Examination Category B-L-2, Pump Casings, and Examination Category B-M-2, Valve Bodies
IWB-3520: standards for examination Category B-N-1, interior of Reactor vessel, examination Category B-N-2, welded core Support structures and Interior attachments to Reactor vessels, and Examination category B-N-3, Removable core support Structures

22.	**Test Results/Conclusion on acceptance of inspection**	ACCEPTABLE/REPAIR/REPLACEMENT

Signature	Signature	Signature	Signature
(Name)	(Name)	(Name)	(Name)
Performed by	Checked by	Reviewed by	Accepted by

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)

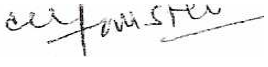
DIRECTORATE OF QUALITY ASSURANCE

PROCEDURE NO.: PP-P-2009 REV. 2

TITLE	PROCEDURE FOR ULTRASONIC EXAMINATION OF PRESSURE RETAINING WELDS OF PIPING & VESSEL BUTT-WELD JOINTS

REVISION NO.	0	1	2
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	NAME	SIGNATURE	DATE
PREPARED BY	P.V. Khambatkone ACE (QA)		March 2001
REVIEWED BY	M. Mohan Babu, ACE (ISI)		March 2001
APPROVED BY	C. Awasthi, ED (QA)		March 2001

REVISION CONTROL SHEET

PROCEDURE NO.: PP-P-2009 REV. 2

PROCEDURE FOR ULTRASONIC EXAMINATION OF PRESSURE RETAINING WELDS OF PIPING & VESSEL BUTT-WELD JOINTS

Rev. No. & date	Description of Revision	Prepared / Revised By	Reviewed By	Approved By
1 May 2007	Editorial changes and changes as per latest codes/ standards	P.V. Khambatkone CE (QA) A.K. Palit, CE(QA)	M. Mohan Babu CE (ISIS), QA	M. Mohan Babu CE (ISIS), QA
2 Feb. 2013	Editorial changes and changes as per latest codes/ standards	A.K. Palit, CE(QA)	A. K. Palit, CE (QA)	K. P. Dwivedi ED (QA)

1.0 SCOPE

This Procedure describes the requirements for ultrasonic testing (UT), by Pulse-Echo Contact method by manual scanning, of pressure retaining weld joints in steel piping and vessels of 5 mm to 150 mm nominal wall thickness. While the procedure has been prepared for ferritic similar material full penetration butt welds, it may be applied with discretion to dissimilar metal welds, austenitic stainless steel welds, fillet welds and for welds where clad is present.

2.0 REFERENCE

This document is based on the following:

(a) ASME Boiler & Pressure Vessel Code, Section V, Article 5 (2010 Edition)

(b) ASME Boiler & Pressure Vessel Code, Section VIII, Division 1 (2010 Edition)

(c) ASME Boiler & Pressure Vessel Code, Section III, NB, NC (2010 Edition)

(d) PP-P-1981 Rev-2

3.0 PERSONNEL QUALIFICATION

Scanning shall be carried out by personnel qualified by the ISNT or the ASNT to UT Level I or higher. Verification of calibration, scanning, analysis of indications and reporting shall be by personnel qualified by the ISNT or the ASNT to UT Level II or higher. The Head of the QA Unit may conduct evaluation tests to check the theoretical and practical capability of the personnel performing UT.

4.0 INSTRUMENTATION

4.1 Equipment

A standard ultrasonic flaw detector shall be used, which operates on the pulse-echo method, is capable of operating at frequencies of 1MHz to 5MHz and satisfying the requirements of Appendix-1 of PP-P-1981 Rev-2, attached as Annexure 3. The following list is not exclusive.

Sonic, USA	- FTS Mk I, Mk IV
Krautkrämer, Germany	- USM 2, USIP 12, USD 30, USL 48M
EEC, India	- ESM-2, ESM-2M, EX-10, EX-100, EECOSCAN
Modsonic, India	- Einstein, all Models

4.2 Probes

The following combination of search units / probes is recommended for use with different thicknesses, however any other suitable combination of probes may be used if that gives the required sensitivity

From (Mm)	To (Mm)	Frequency (Mhz)	Approximate Size (Mm)	Normal Probe Type	Beam Angle
5	20	2 OR 4	6Φ, 10×12 OR 4×9	SINGLE/ DUAL	45º & 70º OR 60º
20	30	2 OR 4	10Φ, 8×9 OR 10×12	SINGLE/ DUAL	45º & 70º OR 60º
30	40	2 OR 4	10Φ, 8×9 OR 10×12	SINGLE	45º & 60º
40	Onwards	2, 2.25 OR 4	24Φ OR 20×22	SINGLE	45º & 60º

NOTE: PROBES WITH MATCHING CURVED SHOES ARE RECOMMENDED FOR PIPING BELOW 50MM NB.

4.3 Testing technique Contact method

4.3.1 Examination Coverage:

The entire volume of the weld and heat affected zone (minimum 12 mm on either side of weld profile) shall be covered by manual scanning and visual monitoring with 10% overlap of transducer dimension perpendicular to direction of scan.

4.3.2 Rate of search unit movement: The maximum rate of probe (search unit) movement shall be established by moving the probe on the calibration block for which the amplitude from reflector notch shall be at least 50% of the reference amplitude when picked up at a distance of full vee path for outer notch and be not less than 60% of the reference amplitude when at a distance of ½ vee path. However the rate of search unit movement for examination shall not exceed 150mm per second.

5.0 CALIBRATION

5.1 Calibration Block

5.1.1 The Basic Calibration Block shall be as shown in Annexure-2A. The basic calibration reflectors shall be located in the Basic Calibration Block. When block thickness 25 mm spans two of the weld thickness range, then the block used shall be acceptable in those portions of each thickness range covered by 25 mm. For angle beam calibration for pipes, the calibration block shall be with square notches on the inside and outside surface of the pipe weld as shown in Annexure-2B. Diameter shall meet requirements of Paragraph 5.1.5. Notch dimensions shall be measured and recorded.

5.1.2 The calibration block shall be of the same product form and material specification or the equivalent P-No., as defined in ASME Section IX, Welding Qualifications. For calibration blocks for dissimilar metal welds, the material selection shall be based on the side of the weld from which the examination will be conducted. Where two or

more material thicknesses are involved, the calibration block shall be determined by the average thickness of the weld.

5.1.3 The calibration block shall receive the same type of heat-treatment as the material specification.

5.1.4 Ensure that the calibration block shall be free of defects interfering with its purpose. For this purpose, the calibration block material shall be completely examined by normal beam. Any areas that contain an indication exceeding the back reflection (at the spot) shall be noted. Such portions shall be excluded from beam paths required to search the various calibration reflectors.

5.1.5 For examination in materials where the examination diameter is more than 500mm, a block of essentially the same curvature or alternatively a flat basic calibration block shall be used. For diameter 500mm or less, a curved basic calibration block may be used to calibrate the examination on surface in the range from 0.9 to 1.5 times the basic calibration block diameter.

5.1.6 The surface finish of the calibration block shall be representative of the surface finish on the component being examined.

6.0 SYSTEM CALIBRATION

6.1 Straight beam calibration shall provide sweep range calibration and distance amplitude correction (DAC). When an electronic distance amplitude correction device is used, the primary reference response / level (PRL) shall be equalised on the basic calibration block to 80% of full screen height (FSH) over a distance range to be employed in the examination.

6.2 Angle beam calibration shall provide the following measurements:

6.2.1 Sweep range calibration.

6.2.2 Distance amplitude correction: (for material thickness less than 25mm and testing limited to half Vee path, DAC curve is not necessary).

6.3 Calibration check on basic calibration block shall be made when any part of examination system (including personnel) is changed or in the beginning / end of shift or work/ every 4hrs, to verify 1/4, 1/2 and 3/4' T' points on sweep and DAC values recorded satisfy the requirements given above.

6.4 Calibration shall be confirmed for sweep range and DAC prior to use of the system in the thickness range under examination.

6.5 During each recalibration, check the existing calibration on the instrument. If it is found that the gain has changed by ± 20% or 2 dB or that the sweep has changed by ± 10%, discard results belonging to the earlier calibration. Rescan all applicable areas.

7.0 SURFACE CONDITION

The contact surfaces shall be free from weld spatter, roughness or other conditions which interfere with free movement of search unit or which can impair the transmission of ultrasound in the job. Examination shall be conducted on welds and

adjacent base material in their completed surface condition. The surface finish shall be 3 µm or better.

8.0 COUPLANT

Oil, grease, glycerine, water or cellulose paste shall be used as couplant. Select a suitable couplant based on the surface conditions and orientation; roughness and non-horizontal conditions require a more viscous couplant. Any requirements for protection of the material under test, such as for sulphur and halogen content, shall be met by the couplant.

9.0 SCANNING

9.1 The normal scanning of the base material adjacent to the weld region shall be carried out to detect reflectors that might affect interpretation of angle beam results and is not to be used as an acceptance/ rejection examination. Location of such reflectors shall be recorded.

9.2 Weld and base metal shall be scanned up to a distance of 3T on both side of weld, where T is thickness of thicker plate with the straight beam search unit. The scanning shall be done at least twice the PRL or +6dB. Evaluation shall be done at PRL.

9.3 Scanning shall be done with angle beam directed at approximately right angle to the weld axis from two directions whenever possible. The search unit shall be manipulated so as to maximise the response from the possible defect. Scanning shall be done at least twice the gain setting for PRL. The evaluation shall be done at PRL. Scanning shall be done with a set of two probe combination as recommended in paragraph 4.2 above to ensure proper evaluation of the indication detected.

9.4 Angle beam scanning shall also be done with beam directed essentially parallel to the weld axis. The search unit shall be manipulated so as to maximise the response from the possible defect. Scanning shall be done at a gain twice the PRL and on completion of the scan in one direction, the search unit shall be rotated 180° to repeat the examination in the opposite direction.

9.5 In general scanning shall be done from outside / top side of weldment. In case of inaccessibility scanning can be done from other side / surface.

10.0 EVALUATION & RECORDING

The evaluation shall be conducted at PRL, i.e., any additional gain used for scanning shall be removed. Any imperfection which causes an indication in excess of 20% of DAC shall be recorded with respect to location, response level, dimension, depth below the reference, classification of indication in a report format (Annexure-1) and investigated to the extent that it can be evaluated in terms of relevant acceptance standard. If any repair is to be carried out, it shall be done as per relevant procedure and re-examination of the repaired area shall be done as per the same procedure as used for the original detection of defect. The repaired area shall be marked ‘R1’, ‘R2’etc.

11.0 ACCEPTANCE STANDARD

11.1 Indication characterised as crack, lack of fusion or incomplete penetration, are unacceptable regardless of length.

11.2 Other imperfections are unacceptable if amplitude exceeds the PRL, and discontinuities have lengths which exceed following:

6mm for 't' up to 19mm inclusive,

1/3't' for 't' from 19mm to 57mm.

19mm for 't' over 57mm

where 't' is the thickness of the weld excluding any allowable reinforcement. If a weld joint has two different thicknesses, then 't' is the thinner of the two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in 't'.

12.0 POST EXAMINATION CLEANING:

After the examination the test surface shall be thoroughly cleaned free from grease, oil etc., using dry cloth, acetone etc.

ANNEXURE-1

ULTRASONIC EXAMINATION REPORT FOR WELD JOINT

PROCEDURE NO.....REPORT NO..... DATE.....

COMPONENT DETAIL.....

SPECIFICATIONS.....ACCEPTANCE STANDARD.....…….

PROBE	MAKE	TYPE	FREQUENCY

CALIBRATION BLOCK..... REF. ECHO APPLICABLE.....

CALIBRATION RANGE.....COUPLANT.....

TYPE OF JOINT..... SURFACE CONDITION.....

MATERIAL.....O.D.....SCH..... THICKNESS.....

SCANNING TECHNIQUE.....

DAC CALIBRATION DETAILS:

RANGE CALIBRATION AMPLITUDE CALIBRATION

SR. NO.	TIME(HRS)	CAL. REFLECTOR DISTANCE (MM)	RESPECTIVE ECHO POSITION (DIV.)	BACK WALL ECHO (%)	GAIN (dB) COARSE + FINE

UT EXAMINATION : DATA RECORD OF OBSERVATIONS

INDICATION SERIAL NO.:

SCAN DIRECTION : SIDE / ANGLE:

DISTANCE ALONG WELD FROM L_O:

MAXIMUM INDICATION AMPLITUDE:

% DAC: DISTANCE TO WELD CENTRE LINE: SWEEP READING:

THROUGH DEPTH / SIZE :

DISTANCE FROM TOP SURFACE:

TYPE OF DEFECT INDICATION:

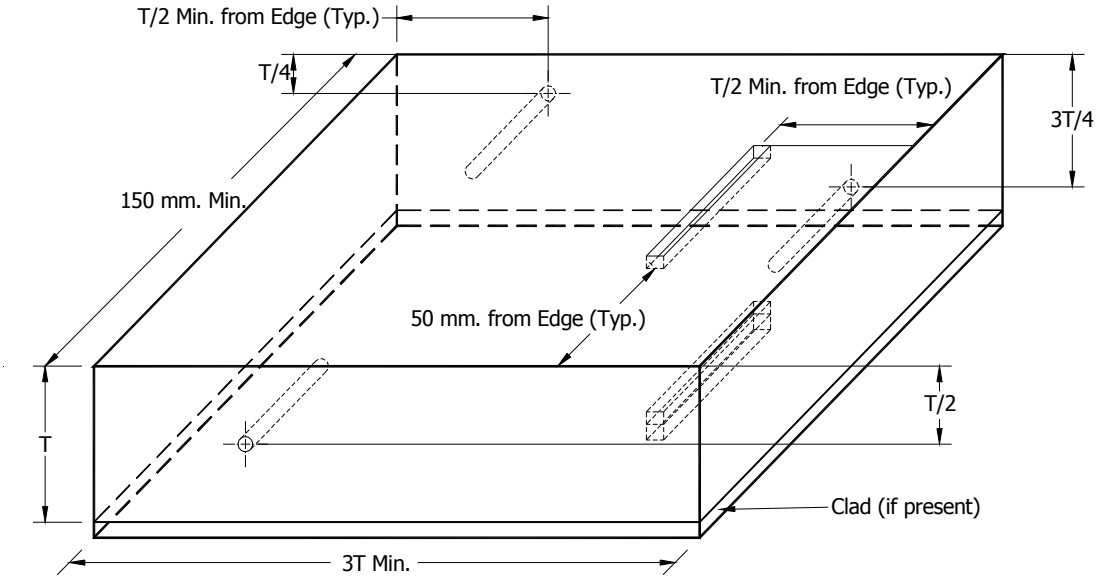
REMARKS: ACCEPTABLE / REJECTED / REPAIR

U.T.EXAMINATION DONE BY:..... WITNESSED BY:.....

EVALUATED & CERTIFIED BY:.....

ANNEXURE 2A (2 PAGES)

BASIC CALIBRATION BLOCK (From Fig. T-434.2.1, Section V, ASME)



Weld thickness t	Basic Calibration Block thickness T	Hole Diameter	Notch Size
25 mm or less	19 mm or t	2.4 mm	Width = 3.5 to 6 mm Depth =2% T or 1 mm, whichever is greater, in the base metal. Length = 50 mm Min.
Over 25 mm through 50 mm	38 mm or t	3.2 mm	
Over 50 mm through 100 mm	75 mm or t	4.8 mm	
Over 100 mm through 150 mm	125 mm or t	6.4 mm	
Over 150 mm through 200 mm	175 mm or t	8 mm	
Over 200 mm through 250 mm	225 mm or t	9.6 mm	
Over 250 mm	t = 250 mm	[Note]	

GENERAL NOTES:

(a) Holes shall be drilled and reamed a minimum of 40 mm deep, essentially parallel to the examination surface.

(b) Notches may be made by EDM or with end mill.

(c) Curved surface:Two curved blocks, one for each representative curvature; or two sets of calibration reflectors (holes, notches)oriented 90° from each other shall be used. Alternatively, two curved calibration blocks shall be used.

(d) For components equal to or less than 500mm in diameter, Calibration block diameter shall meet the requirement of T434.1.7.2 Article 4, ASME Section V.

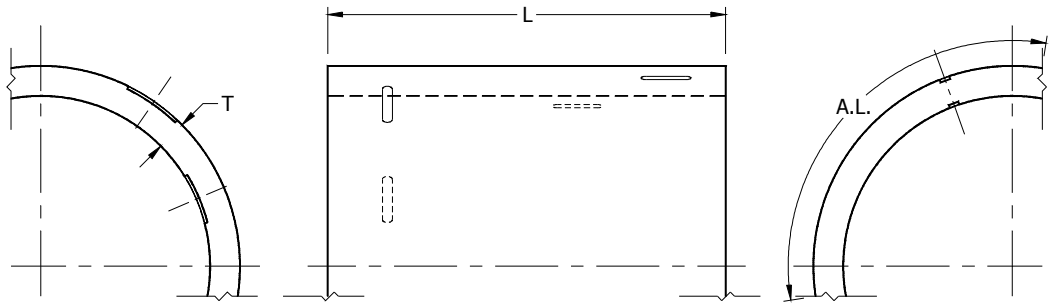
(e) Notches may be provided as required.

(f) The tolerance for hole diameter shall be ± 0.8 mm. Tolerance for hole location ie. the distance from examination surface shall be +/- 3mm. Notch depth shall be 1.6T minimum to 2.2% maximum

Note: For each increase in weld thickness of 50 mm of fraction thereof over 250 mm, the hole diameter shall increase 1.6 mm.

ANNEXURE 2B

ANGLE BEAM CALIBRATION (PIPE WELDS) (From Fig. T-434.2.1, ASME Sec. V)



TYPICAL BLOCK DIMENSIONS

Length L = 250 mm or 8T, whichever is greater.
Minimum Arc Length (A.L.):

(1) For O.D. 100 mm or less: 270°.
(2) For O.D. greater than 100 mm: the greater of 3T or 200 mm.

SPECIFIC NOTCH DIMENSIONS

Length: 25 mm minimum
Depth: 3 % T with tolerance (+ 10%, - 20%) of depth
Width: 3.5 to 6 mm
Location: Not closer than T from block edge.

ANNEXURE 3

(Appendix 1 to PP-P-1981, R-2 Performance Checks of UT Instrument)

A. SCOPE

This Appendix describes the procedures to be followed and provides the requirements to be met to check and confirm that an ultrasonic test instrument is performing adequately, if such a check is required by a Specification or Procedure.

In using the following directions, indications may need to be maintained on the screen over a length of time, with assurance that there is no change in received echo energy. An immersion fixture with an immersion probe can be very convenient for maintaining this constancy over this period. However, use of such a fixture is not mandatory, though then, care has to be taken that changes do not take place and a recheck shall particularly be done with the old control settings.

If the performance of the instrument does not meet the requirements, it shall be serviced and all performance parameters re-evaluated. Such servicing is not within the purview of UT personnel, but must be conducted by the manufacturer, their authorized agents or other electronic servicing personnel of adequate electronic capability.

B. AMPLITUDE LINEARITY

This parameter is also called “Screen Height Linearity”.

Use any convenient angle beam probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up two simultaneous indications from ½ and 3/4T side drilled holes in any convenient test piece or block which can adjusted such as to provide a ratio of 1:2 between indication heights. That is, one echo must be twice the height of the other. It is immaterial which echo appears first on the time-base.

In order to obtain this condition, one method is to obtain a stepped block (i.e. one with two distinct thicknesses) and scan it from the un-stepped flat side. On scanning the zone of thickness change, two echoes, backwall echoes from the two thicknesses, will be obtained. By selecting an appropriate probe position, the two echoes can be set at any amplitude ratio to each other, in this case, 1:2 or 2:1. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of the bigger of the two echoes to 80 % full-screen-height.

Without permitting probe movement, re-adjust any of the above controls to change the amplitude of the larger of the two echoes successively from 100 % to 20 % in steps of 10 % full-screen-height. Record the amplitude of the smaller echo in each case. This value must be within 5 % full-screen-height of half the bigger echo, rounded off to the nearest 1 %.

For example, for the case of the bigger echo being at 60 %, the smaller echo must be within the range of 30 % full-screen-height, ± 5 % .

Values outside these call for instrument servicing.

C. AMPLITUDE CONTROL LINEARITY

Use any convenient probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up any indication from 1/2T side drilled hole in any convenient test piece or block which can readily be picked by the probe and maintained stable. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of this echo to 80 % full-screen-height. Only the Gain control or controls shall be adjusted further. Without permitting probe movement, change the Gain by ± 6 dB and ± 12 dB and record the amplitudes.

The table below gives the requirements:

Initial amplitude set at % of full screen	Gain Control Change	Acceptance Limits of Amplitude % of full Screen
80 %	- 6 dB	32 to 48 %
80 %	- 12 dB	16 to 24 %
40 %	+ 6 dB	64 to 96 %
20 %	+ 12 dB	72 to 88 %

The settings and readings shall be estimated to the nearest 1% of full screen.

This check shall be done starting with many representative values of Gain, such that the performance of the Gain control system is evaluated over the entire range of gain control. Where more than one calibrated Gain control is available, such as two separate knobs, each of them shall be checked over their range of control. In order to check the gain controls at various ranges, other controls such as Damping and Filter may be set at different combinations at the start of each test sequence of varying the Gain by ± 6 and ± 12 dB.

The values of 6 and 12 dB may be obtained by combining two of the controls.

When not using the DGS method, depending on the application, it may be adequate to limit the check to the general range of values in use during actual scans.

D. INSTRUMENT TIME -BASE LINEARITY

This parameter shall be checked at or near range values corresponding to those normally in use.

In the following descriptions, the percentage values refer to the time-base, 0 % and 100 % being the left and right hand extreme graduations.

Select a block of uniform thickness of approximately one-fifth of the range to be checked. Use any convenient normal beam probe, and suitable settings for control settings other than those related to the time-base. Calibrate the instrument time-base to five times this thickness, by positioning the second back-wall echo to 40 % and third back-wall echo to 60 % of the screen. This would require adjustments to the

Range, Material Calibration and Delay controls or their equivalent. Lock all of these controls other than Delay.

Using Delay, shift the second back-wall echo to a selected screen division and record the position of the next echo, i.e. the third back-wall echo. Selected screen divisions, in turn, shall be zero, 20 %, 40 % and 80 %. The expected reading shall, in each case be obviously 20 % larger than the selected screen division.

In each case the permissible error from expected reading shall be within 2 % of the time-base. In instruments with a total of 50 divisions for the time-base, this will correspond to one such small division.

In many instruments, the display does not extend beyond the final time-base mark. In such cases, the check of the last point shall be done in reverse, by shifting the third back-wall echo to the last mark and reading the position of the second back-wall echo.

Specifically in the case of the initial or last portions of the time-base twice the error of 2 %, i.e. 4 % may be permitted. This however, is conditional on checks of the 5 to 25 % or the 75 to 95 % or both respectively, additionally being done and the results being within 2 %, (in instruments with 2% as the small division size, these values may be changed to 6 to 26 % and 76 to 96 % respectively).

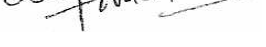
NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

PROCEDURE NO.: PP-P-2010 REV. NO. 2

TITLE	PROCEDURE FOR ULTRASONIC EXAMINATION OF BUTT & FILLET WELD JOINTS IN STRUCTURAL STEEL FABRICATION

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REVIEWED BY	M. Mohan Babu, ACE (ISI)		March 2001
APPROVED BY	C. Awasthi, ED (QA)		March 2001

REVISION CONTROL SHEET

PROCEDURE

NO.: PP-P-2010 REV. NO. 2

PROCEDURE FOR ULTRASONIC EXAMINATION OF BUTT & FILLET WELD JOINTS IN STRUCTURAL STEEL FABRICATION

Rev. No. & date	Description of Revision	Revised By	Reviewed By	Approved By
1 May 2007	Editorial changes and changes as per latest codes/ standards	P.V. Khambatkone CE (QA) A.K. Palit, CE(QA)	M. Mohan Babu CE (ISIS), QA	M. Mohan Babu CE (ISIS), QA
2 Feb. 2013	Editorial changes and changes as per latest codes/ standards	A. K. Palit CE(QA)	A. K. Palit CE(QA)	K. P. Dwivedi ED (QA)

1.0 SCOPE

This Procedure describes the requirements of ultrasonic testing (UT), by Pulse-Echo Contact method, by manual scanning, of Butt and Fillet welds of 5 mm to 200 mm thickness in structural steel fabrication.

2.0 REFERENCE

This document is based on the following

a) ASME-V Art. 5 (2010 Edition)
b) ASME-VIII-Div-1 (2010 Edition)
c) PP-P-1981 Rev.2 , General Requirements for Ultrasonic Examination Procedures
d) ASTM E-164 Standard Practice for Ultrasonic Contact Examination of Weldments

3.0 PERSONNEL QUALIFICATIONS

Scanning shall be carried out by personnel having current valid qualification to UT Level I (ISNT/ASNT). Verification of calibration, scanning, analysis of indications and reporting shall be by personnel qualified to UT Level II (ISNT/ASNT). However, Head QA or Superintendent QA of the Unit shall have the authority and responsibility to conduct evaluation tests to check the theoretical and practical capability of examination personnel.

4.0 INSTRUMENTATION

4.1 Equipment

A standard ultrasonic flaw detector operating on the pulse-echo method, capable of generating frequencies from 1MHz to 5MHz, and satisfying the requirements of Annexure 3, shall be used. Microprocessor based instruments may also be used. The following list is not exclusive.

Sl.	Models	Models
1	M/s. Roop Ultrasonix, India.	4400, 440A, 4400M
2	M/s. Electronic and Engineering Co., India	ESM-2, 2M, EX-10,100
3	M/s Modsonic	Einstein
4	M/s. Krautkramer, Germany, USA	USIP11, USD10, USL 48
5	M/s. Karl Deutsch, Germany	1023, 1024, 1025, 1030
6	M/s. Panametrics, USA.	Epoch-2000, Epoch-II
7	M/s. Sonic, USA.	FTS MK-I, FTS MK-IV

However, the Head QA or Superintendent QA of the applicable Unit shall have the authority and responsibility to permit use of any other equipment which meets the requirements of Annexure 3.

4.2 Search Units / Probes

The table given below gives the combination of search units / probes recommended for use with different thicknesses, however, any other suitable combination may also be used which gives the required sensitivity. Further, the attached Table-2 (from ASTM-E-164) gives the recommended techniques for which these combinations can be used effectively.

PROBE RECOMMENDATIONS

From (Mm)	Up To (Mm)	Frequency (Mhz)	Approximate Dimensions (Mm)	Single/Dual	Beam Angle
5	12	2 / 4	8×9/10×12/4×9	Single/Dual	0°, & 45° / 70°
12	38	2 / 4	10 φ /8×9/10×12	Single/Single	0°, & 45° / 70°
38	63	2 / 4	10 φ /8×9/10×12	Single/Single	0°, & 45° / 70°
63	Onwards	2.25 / 4	24 φ /20×22	Single/Single	0°, & 45° / 70°

4.3 Testing technique: Contact method

4.3.1 Examination Coverage: The entire volume of the weld shall be covered by manual scanning and visual monitoring with 10% overlap of transducer dimension perpendicular to direction of scan.

4.3.2 Rate of search unit movement: The rate of search unit movement for examination shall not exceed 150 mm per second unless calibration is verified at that scanning speed.

5.0 CALIBRATION

5.1 Calibration Block

5.1.1 The Basic Calibration Block shall be as shown in figure-T-542.2.1 Article 5 of ASME-V (Annexure-1). The basic calibration reflector shall be located in the Basic Calibration Block. When block thickness ±25mm spans two of the weld thickness range, then the block used shall be acceptable in those portions of each thickness range covered by 25mm.

5.1.2 The calibration block shall be of the same product form and material specification or the equivalent P-group no. For calibration blocks for dissimilar metal welds, the material selection shall be based on the side of the weld from which the examination will be conducted. Where two or more material thicknesses are involved, the calibration block shall be determined by the average thickness of the weld.

5.1.3 The calibration block shall receive the same type of heat-treatment as the material specification.

5.1.4 The calibration block material shall be completely examined by normal beam search unit and the areas that contain an indication exceeding the remaining back reflection shall be excluded from beam paths required to search the various calibration reflectors.

5.1.5 For examination in materials where the examination diameter is more than 500mm, a block of essentially the same curvature or alternatively a flat basic calibration block shall be used. For diameter 500mm or less, a curved basic calibration block may be used to calibrate the examination on surface in the range from 0.9 to 1.5 times the basic calibration block diameter.

5.1.6 The surface finish of the calibration block shall be representative of the surface finish on the component being examined.

6.0 SYSTEM CALIBRATION

6.1 Straight beam calibration shall provide sweep range calibration and distance amplitude correction (DAC). When an electronic distance amplitude correction device is used, the primary reference response / level (PRL) shall be equalised on the basic calibration block at 80% of full screen height (FSH) over a distance range to be employed in the examination.

6.2 Angle beam calibration shall provide the following measurements

6.2.1 Sweep range calibration.

6.2.2 Distance amplitude correction (for material thickness less than 25mm and testing limited to half Vee-path, DAC curve is not necessary). When an electronic distance amplitude correction device is used, the primary reference response / level (PRL) shall be equalised on the basic calibration block at 80% of full screen height (FSH).

6.2.3 Position calibration.

6.2.4 Echo Amplitude measurement from the surface notch in the calibration block.

6.3 Calibration check on basic calibration block shall be made when any part of examination system (including personnel) is changed or in the beginning / end of shift or work/ every 4hrs, to verify 1/4, 1/2 and 3/4' T' points on sweep and DAC values recorded satisfy the requirements given above.

6.4 Calibration shall be confirmed for sweep range and DAC prior to use of the system in the thickness range under examination.

6.5 If a point on DAC curve has moved on the sweep line more than 10% of the sweep reading, or 5% of full sweep whichever is greater, correct the sweep range calibration and note the correction in the examination record. If reflectors are recorded on the data sheets those sheets shall be voided and new calibration shall be recorded. All recorded indications since the last valid calibration shall be re-examined with the corrected calibration and their values shall be changed on data sheets.

6.6 If a point on DAC curve has decreased 20% or 2dB of its amplitude, all data sheets since the last calibration / calibration check shall be marked void. A new calibration shall be made and recorded. The area covered by invalid data, shall be re-examined. If any point on DAC curve has increased more than 20% or 2dB of its amplitude, all recorded indications since the last valid calibration, shall be re-examined with the corrected calibration and their values shall be changed on the data sheets.

7.0 SURFACE CONDITION:

The contact surfaces shall be free from weld spatter, roughness or other conditions which interfere with free movement of search unit or which can impair the transmission of ultrasound in the job. Examination shall be conducted on welds and the heat affected zone in the adjacent base material in their completed surface condition. The surface finish shall be 3 µm or better.

8.0 COUPLANT

Oil, grease, glycerine with water or cellulose paste shall be used as couplant.

9.0 SCANNING

9.1 The normal scanning of the base material adjacent to the weld, shall be carried out to detect reflectors that might affect interpretation of angle beam results and is not to be used as an acceptance / rejection examination. Location of such reflectors shall be recorded.

9.2 Weld and base metal shall be scanned up to a distance of 3T or 12mm minimum on both sides of weld, where T is thickness of thicker plate with the normal beam search unit. The scanning shall be done at least twice the PRL or +6dB. Evaluation shall be done at PRL.

9.3 Scanning shall be done with angle beam directed at approximately right angle to the weld axis from two directions whichever possible. The search unit shall be manipulated so as to maximise the response from possible defects. Scanning shall be done at least twice the gain setting for PRL. The evaluation shall be done at PRL.

9.4 Angle beam scanning shall also be done with beam directed essentially parallel to the weld axis. The search unit shall be manipulated so as to maximise the response from the possible defect. Scanning shall be done at a gain twice the PRL and search unit to be rotated by 180° to repeat the examination.

9.5 In general scanning shall be done from outside / top side of weldment. In case of inaccessibility scanning can be done from either side / surface. The procedures & techniques, recommended for the common weld configurations, are as per the attached Table-2.

10.0 EVALUATION & RECORDING

Any imperfection which causes an indication in excess of 50% of DAC shall be recorded with respect to location, response level, dimension, depth below the reference, classification of indication in a report format (Annexure-2) and investigated

to the extent that it can be evaluated in terms of relevant acceptance standard. If any repair is to be carried out, it shall be done as per relevant procedure and re-examination of the repaired area shall be done as per the same procedure as used for the original detection of defect. The repaired area shall be marked 'R1', 'R2' etc.

11.0 ACCEPTANCE STANDARD

11.1 Indication characterised as crack, lack of fusion or incomplete penetration, they are unacceptable regardless of length.

11.2 Other imperfections are unacceptable if amplitude exceeds the PRL, and discontinuities have lengths which exceed following

11.2.1 6mm for 't' up to 19mm inclusive.

11.2.2 1/3't' for 't' up to 19mm to 57mm.

11.2.3 19mm for 't' over 57mm where 't' is the thickness of the weld excluding any allowable reinforcement. If a weld joint has two different thicknesses, then 't' is the thinner of the two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in 't'.

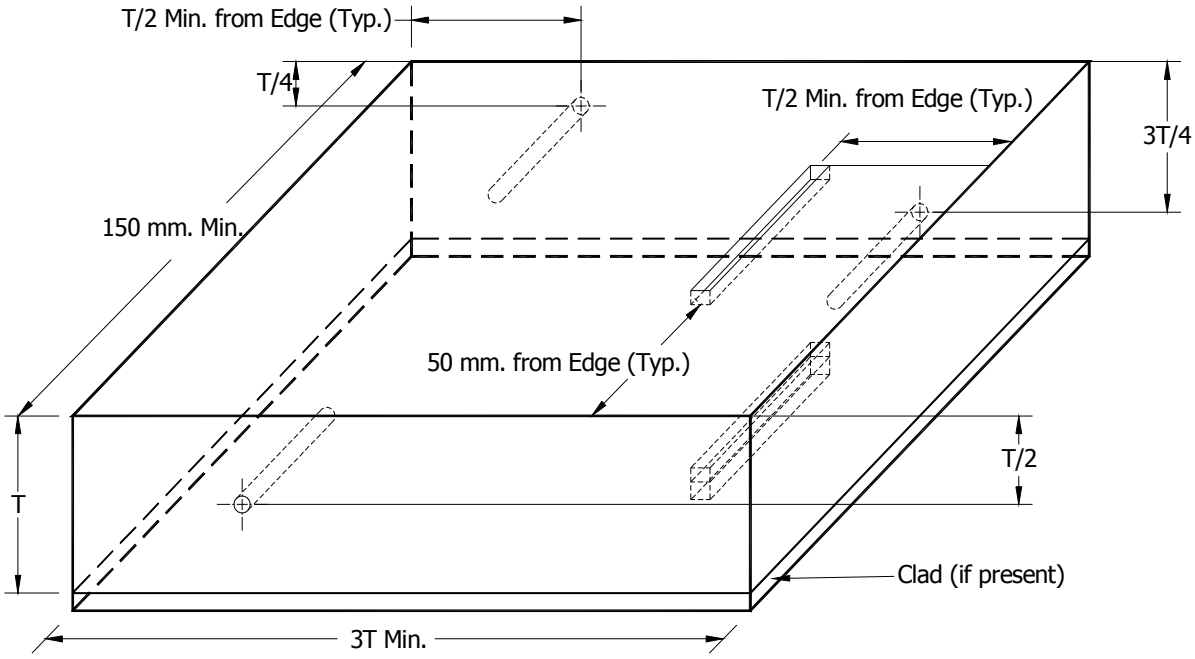
12.0 POST EXAMINATION CLEANING

After the examination the test surface shall be thoroughly cleaned free from grease, oil etc., using dry cloth, acetone etc.

ANNEXURE 1

VESSEL - BASIC CALIBRATION BLOCK

(From Fig. T-542.2.1, Section V, ASME)



Weld thickness t	Basic Calibration Block Thickness T	Hole Diameter	Notch Size
25 mm or less	19 mm or t	2.4 mm	Width = 3.5 to 6 mm Depth = 2 % T or 1 mm, whichever is greater, in the base metal. Length = 50 mm Min.
Over 25 mm through 50 mm	38 mm or t	3.2 mm	
Over 50 mm through 100 mm	75 mm or t	4.8 mm	
Over 100 mm through 150 mm	125 mm or t	6.4 mm	

GENERAL NOTES:

a) Holes shall be drilled and reamed a minimum of 40 mm deep, essentially parallel to the examination surface.

b) Notches may be made by EDM or with end mill.

c) Curved surface: Two curved blocks, one for each representative curvature; or two sets of calibration reflectors (holes, notches)oriented 90° from each other shall be used. Alternatively, two curved calibration blocks shall be used.

d) For components equal to or less than 500mm in diameter, Calibration block diameter shall meet the requirement of T434.1.7.2 Article 4, ASME Section V.

e) Notches may be provided as required.

f) The tolerance for hole diameter shall be ± 0.8 mm. Tolerance for hole location ie. the distance from examination surface shall be +/- 3mm. Notch depth shall be 1.6T minimum to 2.2% maximum

Note: For each increase in weld thickness of 50 mm of fraction thereof over 250 mm, the hole diameter shall increase 1.6 mm.

ANNEXURE 2

ULTRASONIC EXAMINATION REPORT FOR WELD JOINT

PROCEDURE NO..... REPORT NO..... DATE.....
COMPONENT DETAIL.....
SPECIFICATIONS..... ACCEPTANCE STANDARD.....

PROBE	MAKE	TYPE	FREQUENCY

CALIBRATION BLOCK..... REF. ECHO APPLICABLE.....
CALIBRATION RANGE..... COUPLANT.....
TYPE OF JOINT..... SURFACE CONDITION.....
MATERIAL..... THICKNESS.....
SCANNING TECHNIQUE.....

DAC CALIBRATION DETAILS

RANGE CALIBRATION AMPLITUDE CALIBRATION

Sr. No	Time(hrs)	Cal. Reflector distance (mm)	Respective Echo position (Div.)	Back wall Echo (%)	Gain (db) coarse + fine

UT EXAMINATION DATA RECORD OF OBSERVATIONS

INDICATION SERIAL NO.
SCAN DIRECTION: SIDE/ ANGLE
DISTANCE ALONG L0
MAXIMUM INDICATION AMPLITUDE
% DAC: DISTANCE TO WELD CENTRELINE: SWEEP READING
THROUGH DEPTH
DISTANCE FROM TOP SURFACE
TYPE OF DEFECT INDICATION
REMARKS: ACCEPTABLE / REJECTED / REPAIR
U.T. Examination done by:.....
Witnessed by :.....
Evaluated & Certified by :.....

TABLE-2
(from ASTM-E-164)

Procedure recommended for common weld configuration:

WELD TYPE/ THROAT THICKNESS	5MM TO 12MM	12MM TO 38MM	38MM TO 63MM	63MM TO 127MM	127MM TO 200MM
BUTT WELD: SUGGESTED ANGLE/TECHNIQUE	70 / 1,(2/3)	70 OR 60 / 1,(2/3)	70, 60 OR 45 / 1,(2/3)	60 OR 45 / 1,(2OR3),4	60 OR 45 / 1,(2 OR 3)
TEE: FACE-A ANGLE/TECHNIQUE FACE-B ANGLE/TECHNIQUE FACE-C ANGLE/TECHNIQUE	70 / 5 70 / 5 0 , 70 / 6, 7	70 OR 60 / 5 70 OR 60 /5 0, (70 OR 45) / 6, 7	70, 60 OR 45 / 5 70, 60 OR 45/5 0 , 45 / 6, 7	60 OR 45 / 5, 4 60 OR 45 / 5, 4 0, 45 / 6, 7	45 / 5, 4 45 / 5, 4 0, 45 / 6,7
CORNER : FACE-A & FACE-B ANGLE/TECHNIQUE FACE-C ANGLE/TECHNIQUE	70 / 8 0 / 9	70 OR 60 / 8 0 / 9	70, 60 OR 45/ 8 0 / 9	60 OR 45 / 8 0 / 9	45 / 8 0 / 9
DOUBLE FILLET CORNER: FACE-A & FACE-B ANGLE/TECHNIQUE	45 / 10, 11	45 / 10, 11	45 / 10, 11	45 / 10, 11	45 / 10,11

NOTE: SEE THE ENSUING FIGURES 1 TO 14 FOR ILLUSTRATION OF THE ABOVE TECHNIQUES.

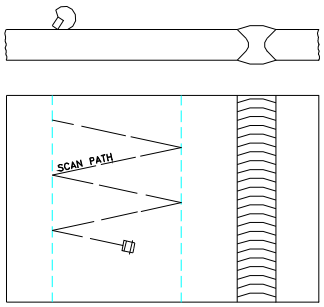


FIG:1 Technique 1, for Inspecting Butt Welds with Angle Beams

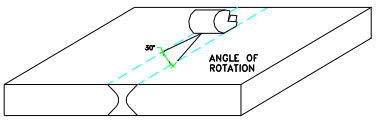


FIG:3 Supplementary Technique 2, for Inspecting Butt Weld for Suspected Cross-Cracking when the Weld Bend is Ground Flush

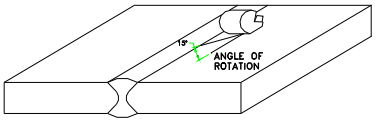


FIG:3 Supplementary Technique 3, for Inspecting Butt Weld for Suspected Cross-Cracking when the Weld Bend is not Ground

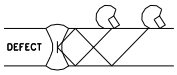


FIG.4 Two-Search-Unit Technique 4, for Use with Thick Weldments

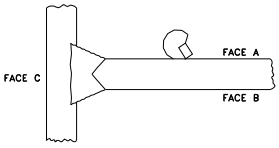


FIG.5 Technique 5, for Inspecting the Weld Volume of T-Welds

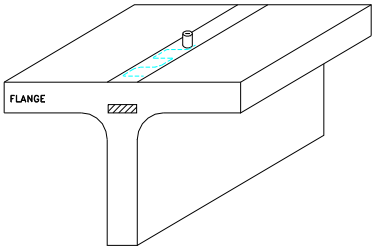


FIG:6 Technique 6, for Inspecting the Fusion Zone of T-Welds

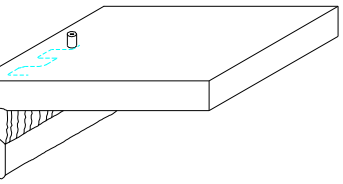


FIG:9 Technique 9, for Inspecting the Fusion Zone of Double Corner Welds

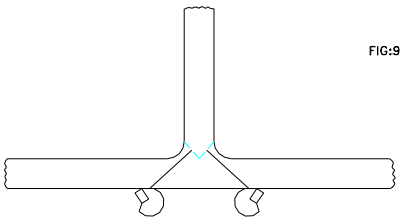


FIG.7(a) Technique 7, for Searching T-Welds for Discontinuities

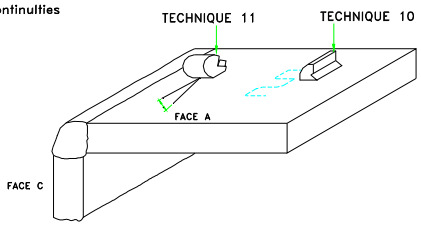


FIG:10 Technique 10 & 11, for Inspecting Full-Penetraks Double-Fillet Corner Welds

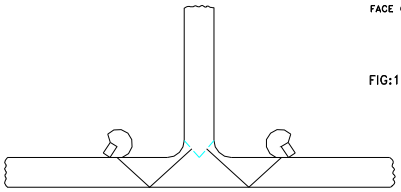


FIG.7(b) Alternative Technique 7, for Searching T-Welds for Discontinuities

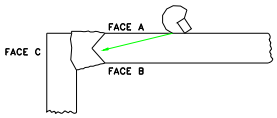
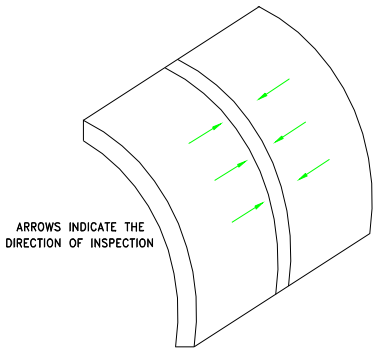
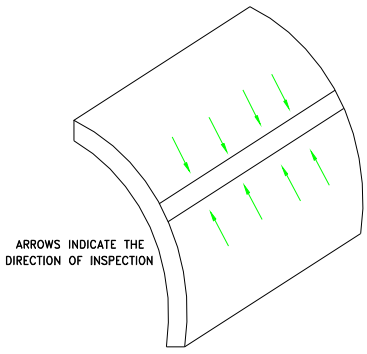


FIG.8 Technique 8, for Inspecting the Weld Volume of Double-Vee Corner Welds



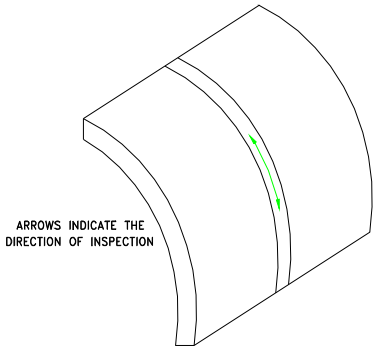
Note : Search-unit shoes are machined to match the curvature of the work piece when diameter is less than 20 in. (500 mm).

FIG.11 Technique 12, for Inspecting Circumferential Welds



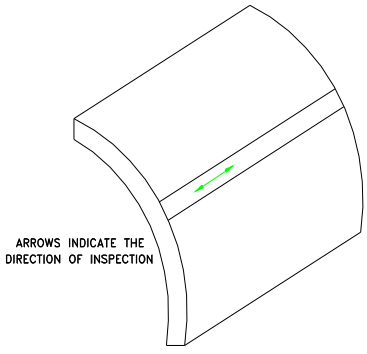
Note : Search-unit shoes are machined to match the curvature of the work piece when diameter is less than 20 in. (500 mm).

FIG.13 Technique 14, for Inspecting Longitudinal Welds



Note : Search-unit shoes are machined to match the curvature of the work piece when diameter is less than 20 in. (500 mm).

FIG.12 Supplementary Technique 13, for Inspecting Circumferential welds, for welds ground Flush



Note : Search-unit shoes are machined to match the curvature of the work piece when diameter is less than 20 in. (500 mm).

FIG.14 Technique 12, supplementary Technique for Inspecting Longitudinal Welds, for Welds Ground Flush

ANNEXURE - 3

(Appendix 1 to PP-P-1981, Performance Checks of UT Instrument)

A. SCOPE

This Appendix describes the procedures to be followed and provides the requirements to be met to check and confirm that an ultrasonic test instrument is performing adequately, if such a check is required by a Specification or Procedure.

In using the following directions, indications may need to be maintained on the screen over a length of time, with assurance that there is no change in received echo energy. An immersion fixture with an immersion probe can be very convenient for maintaining this constancy over this period. However, use of such a fixture is not mandatory, though then, care has to be taken that changes do not take place and a recheck shall particularly be done with the old control settings.

If the performance of the instrument does not meet the requirements, it shall be serviced and all performance parameters re-evaluated. Such servicing is not within the purview of UT personnel, but must be conducted by the manufacturer, their authorized agents or other electronic servicing personnel of adequate electronic capability.

B. AMPLITUDE LINEARITY

This parameter is also called “Screen Height Linearity”.

Use any convenient angle probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up any two simultaneous indications from from ½ and 3/4T side drilled holes in any convenient test piece or block which can adjusted such as to provide a ratio of 1:2 between indication heights. That is, one echo must be twice the height of the other. It is immaterial which echo appears first on the time-base.

In order to obtain this condition, one method is to obtain a stepped block (i.e. one with two distinct thicknesses) and scan it from the un-stepped flat side. On scanning the zone of thickness change, two echoes, backwall echoes from the two thicknesses, will be obtained. By selecting an appropriate probe position, the two echoes can be set at any amplitude ratio to each other, in this case, 1:2 or 2:1. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of the bigger of the two echoes to 80 % full-screen-height.

Without permitting probe movement, re-adjust any of the above controls to change the amplitude of the larger of the two echoes successively from 100 % to 20 % in steps of 10 % full-screen-height. Record the amplitude of the smaller echo in each case. This value must be within 5 % full-screen-height of half the bigger echo, rounded off to the nearest 1 %.

For example, for the case of the bigger echo being at 60 %, the smaller echo must be within the range of 30 % full-screen-height, ± 5 % .

Values outside these call for instrument servicing.

C. AMPLITUDE CONTROL LINEARITY

Use any convenient angle beam probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up any indication from 1/2T side drilled hole in any convenient test piece or block which can readily be picked by the probe any convenient test piece or block which can readily be maintained stable. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of this echo to 80 % full-screen-height. Only the Gain control or controls shall be adjusted further. Without permitting probe movement, change the Gain by ± 6 dB and ± 12 dB and record the amplitudes.

The table below gives the requirements:

Initial amplitude set at % of full screen	Gain Control Change	Acceptance Limits of Amplitude % of full Screen
80 %	- 6 dB	32 to 48 %
80 %	- 12 dB	16 to 24 %
40 %	+ 6 dB	64 to 96 %
20 %	+ 12 dB	64 to 96 %

The settings and readings shall be estimated to the nearest 1% of full screen

This check shall be done starting with many representative values of Gain, such that the performance of the Gain control system is evaluated over the entire range of gain control. Where more than one calibrated Gain control is available, such as two separate knobs, each of them shall be checked over their range of control. In order to check the gain controls at various ranges, other controls such as Damping and Filter may be set at different combinations at the start of each test sequence of varying the Gain by ± 6 and ± 12 dB.

The values of 6 and 12 dB may be obtained by combining two of the controls.

When not using the DGS method, depending on the application, it may be adequate to limit the check to the general range of values in use during actual scans.

D. INSTRUMENT TIME -BASE LINEARITY

This parameter shall be checked at or near range values corresponding to those normally in use.

In the following descriptions, the percentage values refer to the time-base, 0 % and 100 % being the left and right hand extreme graduations.

Select a block of uniform thickness of approximately one-fifth of the range to be checked. Use any convenient normal beam probe, and suitable settings for control settings other than those related to the time-base. Calibrate the instrument time-base to five times this thickness, by positioning the second back-wall echo to 40 % and third back-wall echo to 60 % of the screen. This would require adjustments to the Range, Material Calibration and Delay controls or their equivalent. Lock all of these controls other than Delay.

Using Delay, shift the second back-wall echo to a selected screen division and record the position of the next echo, i.e. the third back-wall echo. Selected screen divisions, in turn, shall be zero, 20 %, 40 % and 80 %. The expected reading shall, in each case be obviously 20 % larger than the selected screen division.

In each case the permissible error from expected reading shall be within 2 % of the time-base. In instruments with a total of 50 divisions for the time-base, this will correspond to one such small division.

In many instruments, the display does not extend beyond the final time-base mark. In such cases, the check of the last point shall be done in reverse, by shifting the third back-wall echo to the last mark and reading the position of the second back-wall echo.

Specifically in the case of the initial or last portions of the time-base twice the error of 2 %, i.e. 4 % may be permitted. This however, is conditional on checks of the 5 to 25 % or the 75 to 95 % or both respectively, additionally being done and the results being within 2 %, (in instruments with 2% as the small division size, these values may be changed to 6 to 26 % and 76 to 96 % respectively).

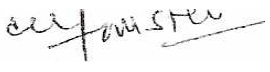
NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

PROCEDURE NO.: PP-P-2011 REV. NO. 2

TITLE	**PROCEDURE FOR ULTRASONIC EXAMINATION OF STEEL PLATE BY MANUAL CONTACT METHOD**

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REVIEWED BY	M. Mohan Babu, ACE (ISI)		March 2001
APPROVED BY	C. Awasthi, ED (QA)		March 2001

REVISION CONTROL SHEET

PROCEDURE

NO.: PP-P-2011 REV. NO. 2

PROCEDURE FOR ULTRASONIC EXAMINATION OF STEEL PLATE BY MANUAL CONTACT METHOD

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1 May 2007	Editorial changes and changes as per latest codes/ standards	P.V. Khambatkone CE (QA) A.K. Palit, CE(QA)	M. Mohan Babu CE (ISIS), QA	M. Mohan Babu CE (ISIS), QA
2 Feb. 2013	Editorial changes and changes as per latest codes/ standards	A.K. Palit, CE(QA)	A. K. Palit CE(QA)	K. P. Dwivedi ED (QA)

1.0 SCOPE

This procedure establishes the requirements for Ultrasonic Testing (UT) of Plate Materials by the manual contact method. This procedure applies to plates of thickness 12mm or larger. The procedure may however be used judiciously, with appropriate probes and test parameters for lower thicknesses, subject to demonstration of effectiveness.

2.0 REFERENCE

(a) ASME Section V Article-5 (Edition-2010).

(b) SA 435, (Edition-2010) Standard specification for Straight beam Ultrasonic testing of steel plates.

(c) SA 577,(Edition-2010) Standard specification for Ultrasonic Angle beam testing of steel plates.

(d) SA 578,(Edition-2010) Standard specification for Straight beam Ultrasonic testing of plain & clad steel plates for special applications.

(e) PP-P- 1981 Rev-2: Requirements for Ultrasonic Examination Procedures.

(f) ASME Sec III NB – 2010 Rules for construction of Nuclear Class - 1 Components.

3.0 EQUIPMENT & ACCESSORIES

3.1 UT Equipment

Pulse echo UT equipment capable of generating frequencies at least 1 MHz to 5 MHz shall be used. Screen height linearity and Amplitude control linearity shall be checked before starting any new job as per Annexure 2 and shall meet the requirements mentioned therein. These checks shall be performed at the beginning of each period of extended use

3.2 Probes

Depending on the application following transducers shall be used:

a) Single, Dual or Delay Block normal beam probes, as appropriate for the job thickness.

b) Angle beam search units (45°, 60°, & 70°)

c) Search unit frequency 2 to 5 MHz.

3.3 Reference calibration blocks

a) IIW V1, V2 blocks shall be used for screen distance range calibration, beam exit point & actual angle of probe.

b) Step wedge block shall be used for calibration of TR probe used for thickness measurement.

c) Ref. Calibration notches shall be used to establish primary reference level/Distance amplitude correction curve for angle beam examination & evaluation.

4.0 COUPLANT

Water or Oil or Grease can be used. Couplant used for calibration shall only be used for examination.

5.0 SURFACE CONDITION

The scanning surface shall be neat & clean, free of dirt, scale, grease paint and other foreign materials. Excessive surface roughness and scratches which interferes with free movement of search unit shall be removed. Surface finish shall be sufficiently clean and smooth to maintain a first back wall reflection shall be at least 50% of full scale during scanning.

PERSONNEL QUALIFICATION

Scanning shall be carried out by personnel qualified by the ISNT or the ASNT to UT Level I or higher. Verification of calibration, scanning, analysis of indications and reporting shall be by personnel qualified by the ISNT or the ASNT to UT Level II or higher. The Head of the QA Unit may conduct evaluation tests to check the theoretical and practical capability of the personnel performing UT.

6.0 DESCRIPTION

6.1 Using Normal Probe (For plate thickness 12 mm and over)

6.1.1 Calibration and Examination (Ref. SA 435 & SA 578)

Transducer shall be 25 mm ϕ size. Dead zone (metal path from the probe front up to which no reflected signal can exist) of the search unit (transducer or probe) shall not be more than 20% of the thickness of the plate under examination when using single probe (search unit). Conduct Examination from any one major surface of the plate. For acceptance of defects in close proximity, inspect from the opposite surface.

Set a convenient range to get back wall echo of the test surface at 75% of full range using delay and range setting knobs.

Scan a few areas of the job to identify a location where the backwall echo is of the highest amplitude. At this location, adjust Gain to obtain the backwall at 70% to 90% of the full screen height (FSH).

Clean and smooth the plate surface to maintain a reference back reflection of the plate at least 50% of Full Screen (FSH) during scanning.

Scan surface along continuous perpendicular grid lines of 225 mm (or any other value as specified) or along continuous parallel path transverse to the plate major axis, on nomonal 100mm centres. In addition to the above scan areas within 50 mm of all edges of the plate.

In case loss of BWE is observed, scan entire surface area of the square around the area of discontinuity to access the area of discontinuity.

Move the transducer away from the center of the discontinuity till height of the back reflection and discontinuity indication are equal. Repeat this in all directions to establish the boundary along the center of the transducer.

Quenched and Tempered plates are to be tested after the heat treatment.

6.1.2 Acceptance criteria-

As per SA 435. Any discontinuity indication causing a total loss of back reflection which cannot be contained within a circle, the diameter of which is 3 in. [75mm] or one half of the plate thickness, whichever is greater, is unacceptable.

As per SA 578

Record all discontinuities causing complete loss of back reflection.For plates 20mm thk and over record all indication equal to or greater than 50% of initial back wall reflection and accompanied by a 50% loss of back reflection.

Level A. Any area where one or more discontinuities produce a continuous total loss of black reflection accompanied by continuous indications on the same plane(within 5% of the plate thickness) that cannot be encompassed within a circle whose diameter is 3 in. [75mm] or ½ of the plate thickness, whichever is greater, is unacceptable.

Level B. Any area where one or more discontinuities produce a continuous indications on the same plane (within 5% of the plate thickness) that cannot be encompassed within a circle whose diameter is 3 in. [75mm] or ½ of the plate thickness, whichever is greater, is unacceptable.

In addition, two or more discontinuities smaller than described as above shall be unacceptable unless separated by a minimum distance equal to the greatest diameter of the larger discontinuity or unless they may be collectively encompassed by the circle described in as above.

Level C. Any area where one or more discontinuities produce a continuous total loss of black reflection accompanied by continuous indications on the same plane(within 5% of the plate thickness) that cannot be encompassed within a circle whose diameter is 1 in. [25mm] or ½ of the plate thickness, which ever is greater, is unacceptable.

6.1.3 Using Angle Beam (Reference SA 577)

This method is for the detection of internal discontinuities not laminar in nature and of surface discontinuities and for use only as a supplement to straight beam ultrasonic examination.

The transducer shall be 45˚ angle beam type of ½" to 1" size, 2 to 5 MHz.

Amplitude of the indication shall yields a signal to Noise ratio at-least equal to 3:1for the highest possible test frequency.

The calibration notch shall be of 1" long and 0.03t depth. For plates up to 2" thickness, one notch on any one surface shall be made as above. For plates of thickness more than 2", one more notch shall be made on the other side also.

Notch or notches need to be perpendicular to the long axis at a distance of 50mm or more from the short edge of the plate and 50mm or more from the long edge of the plate.

When the notches can not be made in the plate to be tested, it may be made in a separate calibration plate of ultrasonically similar material(when the back reflection through it is with in 25% of that through the plate under test).

Place the search unit on the notched surface (for t ≤ 2") and pick the first 'V' path indication of the notch on the screen at 50% to 80% FSH by adjusting gain control knob. Move the transducer away from the notch and pick the 2nd V-path indication. Draw a line connecting the peaks. This is called Distance Amplitude Correction curve (DAC) also called 100% reference line.

For plates over 2" thick, DAC shall be made using outside and inside notches (i.e. ½ V-path, Full V path & 1½V-path with notch indication at 50 to 80% for ½ V-path.)

6.1.3.1 Examination

Scan one major surface of the plate on 9" grid lines(or as specified), Scan the plate in two directions along the end on each grid lines. Scanning shall be done in both directions. Position the search unit to obtain maximum indication amplitude from each observed discontinuity.

Scanning speed shall be less than 150 mm/sec. Minimum overlap shall be 10% of probe size.

For each discontinuity indication that equals or exceeds the DAC, record the location and length, and the amplitude to the nearest 25%. No indication with an amplitude less than the DAC shall be recorded.

At each discontinuity location, conduct 100% examination of the mass under a 9-in. [225-mm] square which has the recorded discontinuity position at its center. Conduct the examination in directions perpendicular and parallel to the major rolling direction.

6.1.3.2 Acceptance criteria

Any discontinuity indication that equals or exceeds the DAC shall be considered unacceptable unless additional exploration by the longitudinal method indicates it is laminar in nature.

7.0 RECALIBRATION

Calibrations, DAC shall be verified,

i) At the start of examination

ii) At least every 4 hrs during examination.

iii) At the finish of the examination.

iv) When there is a doubt on the validity of the calibration.

v) Substitution or any of the following.,

Search unit, cable, power source, couplant, UFD, operator.

8.0 REPORTING

All relevant data of the product, Ref document details, Calibration data and examination results shall be entered in the Proforma enclosed in Annexure-1.

9.0 POST EXAMINATION CLEANING

After the examination the test surface shall be thoroughly cleaned free from grease, oil etc using dry cloth, acetone etc.

Annexure 1

ULTRASONIC EXAMINATATION REPORT			
REPORT NO.:.		DATE OF TESTING :	
REFERENCE PROCEDURE NO.:		WORK ORDER NO. :	
REFERENCE CODE NO.:			
MATERIAL DESCRIPTION			
MATERIAL :		DIMENSIONS:	
IDENTIFICATION:		SURFACE : MACHINED/ROLLED/WELDED CONDITION	
INSTRUMENT DESCRIPTION			
INSTRUMENT USED :	MACHINE No.:	MAKE:	
SEARCH UNIT :		COUPLANT : OIL / WATER	
CALIBRATION			
RANGE CALIBRATION:			
CALIBRATION : STANDARD		SENSITIVITY:	
METHOD & TECHNIQUE:			
EXAMINATION			
SCANNING:			
EXAMINATION STARTED AT : HRS.		CLOSED AT : HRS	
CALIBRATION RECHECKED AT	1. Hrs	2. Hrs	3. Hrs
OBSERVATION OF RECALIBRATION CHECK	1.	2.	3.
OBSERVATION :			
EVALUATION :			

ANNEXURE 2

(Appendix –1 to PP – P– 1981 PERFORMANCE CHECKS OF INSTRUMENT)

A. SCOPE

This Appendix describes the procedures to be followed and the requirements to be met regarding instrument as well as probe performance parameters, as called for in the Specification.

In using the directions to follow, in many cases, indications have to be maintained over a length of time, with assurance that there is no change in received echo energy. An immersion fixture with an immersion probe can be very convenient for maintaining this constancy over this period. However, use of such a fixture is not mandatory, though then, care has to be taken that changes do not take place and a recheck shall particularly be done with the old control settings.

If the performance of the instrument does not meet the requirements, it shall be serviced and all performance parameters re-evaluated. This servicing is not within the purview of UT personnel, but must be conducted by the manufacturer, their authorized agents or other electronic servicing personnel of adequate electronic capability.

B. INSTRUMENT AMPLITUDE LINEARITY

This parameter is also called “Screen Height Linearity”.

Use any convenient angle beam probe. Set the Suppression or Reject control to minimum (or OFF if available) which value shall be left undisturbed throughout. Pick up two indications any from any convenient test piece or block which can adjusted such as to provide a ratio of 1:2 between indication heights. That is, one echo must be twice the height of the other. It is immaterial which echo appears first on the time-base.

In order to obtain this condition, one method is to obtain a stepped block (i.e. one with two distinct thicknesses) and scan it from the un-stepped flat side. On scanning the zone of thickness change, two echoes, backwall echoes from the two thicknesses, will be obtained. By selecting an appropriate probe position, the two echoes can be set at any amplitude ratio to each other, in this case, 1:2 or 2:1. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of the bigger of the two echoes to 80% full screen height (FSH).

Without permitting probe movement, read just any of the above controls to change the amplitude of the larger of the smaller echo successively from 100% to 20% insteps of 10% FSH. Record the amplitude of the smaller echo in each case. This value must be with 5% FSH of half the bigger echo, rounded off to the nearest 1% FSH.

For example, for the case of the bigger echo being at 60%, the smaller echo must be within the range of 30± 5%, i.e. between 25 and 35 FSH.

Value outside these call for instrument rectification as detailed earlier.

C. INSTRUMENT AMPLITUDE COTROL LINEARITY

Use any convenient angle beam probe. Set the Suppression or Reject control to minimum (or OFF if available), which value shall be left undisturbed throughout. Pick up indication from 1/2T side drilled hole in any convenient test piece or block which can readily be picked by the probe and maintained stable. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of the chosen echo to 80% full screen height. Only the Gain control or controls shall be adjusted further. Without permitting probe movement, change the Gain by ± 6 dB and / or 12 dB and record the amplitudes.

The table below gives the requirements.

Initial Set Value of Amplitude	Gain Control Change	Acceptance Limits of Resulting Amplitude.
80%	- 6dB	32 to 48%
80%	- 12dB	16 to 24%
49%	-+6dB	64 to 96%
20%	+12dB	64 to 96%

The settings and readings shall be estimated to the nearest 1% of full screen

This must be 50% and 25% of the original setting, within 10%; i.e., 36 to 44% and 18 to 22% respectively. Values outside these call for instrument rectification as detailed earlier.

This check shall be done starting with many representative values of Gain, such that the performance of the Gain control system is evaluated over the entire range control. Particularly as is usual, where more than one calibrated Gain control is available, such as two separate knobs, all of them shall effectively be checked over their range of control. In order to check the gain controls at various ranges, other controls such as Damping and Filter may be set at different combinations at the start of each test sequence of varying the Gain by ± 6 and 12 dB.

The values of 6 and 12 dB may be obtained by combining two of the controls.

When not using the DGS method, all Gain controls shall be checked. However, the checks may be limited to the general range of values in use during the actual scans.

D. INSTRUMENT TIME – BASE LINEARITY

This parameter shall be checked at or near range values corresponding to those of the shaft step diameters.

In the following descriptions, the percentage values refer to the time-base, 0% and 100% being the left and right hand extreme graduations.

Select a block of uniform thickness of approximately one-fifth of the range to be checked. Use any convenient normal beam probe, and suitable settings for control settings other than those related to the time-base. Calibrate the instrument time-base to five times this thickness, by positioning the second back-wall echo to 40% and third back-wall echo to 60% of the screen. This would require adjustments to the Range, Material Calibration or velocity and Delay controls. Lock all of these controls other than Delay.

Using Delay, shift the second back-wall echo to a selected screen division and record the position of the next echo, i.e. the third back-wall echo. Selected screen divisions shall be zero, 20%, 40% and 80%. The expected reading shall, in each case be obviously 20% larger than the selected screen division.

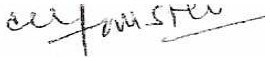
NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

PROCEDURE NO.: PP-P-2012 REV. NO. 2

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APPROVED BY	C. Awasthi, ED (QA)		March 2001

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PROCEDURE

NO.: PP-P-2012 REV. NO. 2

ULTRASONIC EXAMINATION PROCEDURE FOR SHAFT MATERIAL

Rev. No. & date	Description of Revision	Revised By	Reviewed By	Approved By
1 May 2007	Editorial changes and changes as per latest codes/ standards	P.V. Khambatkone CE (QA) A.K. Palit, CE(QA)	M. Mohan Babu CE (ISIS), QA	M. Mohan Babu CE (ISIS), QA
2 Feb. 2013	Editorial changes and changes as per latest codes/ standards	A. K. Palit CE (QA)	A. K. Palit CE (QA)	K. P. Dwivedi ED (QA)

1.0 SCOPE

This procedure describes the requirements for ultrasonic examination of shafts for motors, pumps and similar rotating components for Nuclear Power Plants. This procedure applies to the Pulse – Echo, manual contact method and is applicable to forged shafts and hot rolled or cold rolled bars made from ferritic steels.

2.0 REFERENCES

This document is prepared based on experience, considering that ASME Boiler & Pressure Vessel Code requirements cannot be meaningfully applied for shafts for rotating equipment. Other than methodology and acceptance standards, the following are references:

a) ASME-V Article 5 (2010 Edition)
b) ASME-VIII-Div-1 (2010 Edition)
c) ASME-III NB, NC & ND (2010 Edition)
d) PP-P-1981 Rev.2

3.0 SCAN DIRECTIONS

Three separate scans are required as identified in the following clauses. Separate detailed requirements follow later in this Specification.

3.1 Main Radial Scan

A radial normal beam scan using longitudinal waves shall be conducted. Scan surfaces shall include all cylindrical surfaces of the shaft. This is the main scan and is to be conducted either by the DGS method or the Reference Flat Bottom Hole method, the latter includes use of a Distance Amplitude Correction (DAC) Curve. Both of these alternatives are described in detail later in the text.

3.2 Axial Scan

An axial normal beam scan using longitudinal waves shall be conducted from both ends of the shaft.

3.3 Radial Scan for Grain Size Variations by the Back-wall Method.

A radial normal beam scan using longitudinal waves shall be conducted. Scan surfaces shall include all cylindrical surfaces of the shaft.

4.0 INSTRUMENTATION

A standard ultrasonic flaw detector shall be used, which operates on the pulse-echo method, is capable of operating at frequencies of 1MHz to 5MHz and satisfying the requirements of Annexure 2.

Sonic, USA	- FTS Mk I, Mk IV
Krautkrämer, Germany	- USM 2, USIP 12, USD 30, USL 48M
EEC, India	- ESM-2, ESM-2M, EX-10, EX-100, EECOSCAN
Modsonic, India	- Einstein, all models

The instrument should have adequate sensitivity to display the reference echo of 1% of shaft diameter as defined in the later clause 8, at a height of 80% or more of full screen height (FSH) with at least 6 dB gain reserve (preferably 10 dB). In this

condition, the level of electronic or other "noise" on the screen shall not exceed 20% FSH.

Where evaluation by the DGS method is the option selected, the instrument performance parameters of Amplitude Linearity, Amplitude Control Linearity and Time-base Linearity shall meet the requirements defined in Appendix 1. These parameters shall be checked at the time of commencement of the examination unless valid records less than six months old exist proving conformance and no repair of instrument has been necessitated since.

Witnessing personnel may call for re-checks of these parameters at the start of examination or at any time during examination, if there is reason to doubt instrument performance in these regards.

Witnessing personnel also may call for the above performance parameters to be demonstrated as above, if felt by them to be necessary and relevant, for any scan, irrespective of scan type.

4.1 Probes

Nominally probes of 4 or 5 MHz may be used. Frequencies of 2 MHz to 7.5 MHz are acceptable. Probe selection shall be on the basis of good reserve gain with a clear screen presentation.

4.1.1 Specific Requirements for Probes for the DGS Method

For evaluation by the DGS method, only probes recommended by the manufacturer for such use shall be acceptable. Examples of such suitable probes are the 'D' and 'E' series probes of M/s Krautkrämer or M/s Karl Deutsch provide DGS diagrams. The type data sheets of the manufacturer must certify that the probe is suitable for the DGS method without any cautions or limitations. They may also provide DGS scales, which are also permitted for evaluation.

5.0 CALIBRATION IDENTITY

The same couplant, probe cable and probe shall be used for scanning as those used for calibration. All instrument settings, including time-base controls, controls affecting amplitude such as Filter or Damping and other controls such as PRF shall be unchanged between calibration and scan instructions to follow.

6.0 PERSONNEL QUALIFICATIONS

Scanning shall be carried out by personnel qualified by the ISNT or the ASNT to UT Level I or higher. Verification of calibration, scanning, analysis of indications and reporting shall be by personnel qualified by the ISNT or the ASNT to UT Level II or higher. The Head of the QA Unit may conduct evaluation tests to check the theoretical and practical capability of the personnel performing UT.

7.0 GENERAL REQUIREMENTS

7.1 Shaft

The shaft shall be proof machined at the time of examination. Proof machining shall be such that no keyways, splines or tapers are present. Each step diameter of the shaft shall have a 5 mm radial allowance (10 mm allowance on diameter) Surface finish shall be 3 µm CLA, (equivalent to 125 µm RMS), or better, A so called "gramophone

record" finish shall not be present. The shaft shall be fully "cleaned up" by the proof machining.

7.2 Un-stepped Shafts

It is permissible to examine rolled shafts which are proof machined to only a single uniform diameter; i.e., not proof machined to two or more steps.

7.3 Sensitivity Basis

In the case of stepped as well as un-stepped shafts, the sensitivity requirements shall be based on the final machined diameter applicable at the particular axial and circumferential location.

7.4 Indications Removable in Machining:

Otherwise unacceptable indications, which are clearly demonstrable as removable in further final machining are acceptable, but call for a repeat UT examination after a temporary machining to remove the indication. This machining shall be restricted to the actual volume needing repair. This repeat examination shall be restricted to the actual volume needing reconfirmation and shall meet the requirements of the original examination.

7.5 Couplant

The couplant shall be oil of adequate viscosity to permit scanning without frequent re-application.

7.6 Probe Movement for scanning:

For all scans on the diametral surfaces of the shaft, movement of the probe shall be circumferential. The overlap, which would be axial, shall be at least 10% of the probe diameter.

7.7 Scanning speed

The maximum rate of probe (search unit) movement shall be established by moving the probe on the calibration block for which the amplitude from FBH reflector shall be at least 50% of the PLR. However the scanning speed shall not exceed 150 mm per second.

7.8 Time-Base Calibration Basis

The calibration shall be based on the actual measured shaft diameter (or length) and not based on a separate block such as a reference block.

7.9 Calibration Identity and validity

Any change of instrument or control settings (other than temporary changes of controls which operate on fixed steps), probe, couplant or probe cables shall require re-calibration.

Operating variables including the test instrument, its control settings, its power source, probe, probe cable and couplant shall be unchanged once calibrated through scanning and evaluation, except for re-adjustments of gain between evaluation and scan, as required in latter sections.

After initial calibration, re-checks shall be after every 8 hrs and after the completion of the scan.

7.10 Reject

This control is also called "Suppression" in some instruments and shall be maintained in the minimum position (or OFF position, if available), throughout the examination.

7.11 Continuously Variable Controls

Continuous variable controls such as Damping and Continuously variable Gain shall be maintained at either of the extremes of their positions to the extent possible to avoid inadvertent changes.

8.0 PRIMARY SCAN

The requirements of either one of 8.1 DGS Method or 8.2 Reference FBH Method are applicable.

8.1 Alternative: DGS Method

8.1.1 Time-base calibration

Mechanically measure the shaft diameter within the higher of 1% or 1 mm accuracy. Select a round figure for the required range such as 0 to 100, 0 to 200, 0 to 300, 0 to 400 or 0 to 1000 mm etc. The range shall be such that the first back-wall echo is located between 60% and 90% of the time – base.

Calibrate the time-base position for the first back-well echo. Set the time-base controls such that the second back-wall echo is set to this value, with the first back-wall echo being set to zero. Now, lock all the time-base controls other than Delay. From this setting, use the Delay control to shift the first back-wall echo to the calculated position. The time-base is now calibrated; lock Delay also. Confirm calibration from the position of echoes of other smaller diameter shaft steps wherever possible and correct any errors if necessary.

8.1.2 Amplitude Calibration

Conduct the following steps in sequence

a) At a convenient value of Gain, check several locations of the shaft step at random and find out where the back-wall echo amplitude is highest. Use the calibrated gain controls to set the amplitude at this spot to nominally 80% amplitude, i.e. between 70% FSH and 90% FSH. Note down the gain. This is the Back-wall Reference Gain, (BRG). The nominal value of 80% FSH is hereafter called as Reference Amplitude, (RA).

b) Obtain the required sensitivity as Equivalent Flat Bottom Hole Size, based on 1% of the shaft step diameter, or 2 mm minimum.

c) On the DGS diagram, make a note of two curves. The first curve is the "Back-wall Curve", and is generally marked as "∞", for Infinity. The other curve is one of the flaw evaluation curves; the particular one for the size equal to that of 1% of the shaft diameter, rounded to the nearest 0.5 mm. At the abscissa value equal to the shaft step diameter, note the ordinate difference between the two curves. In dB difference. This dB difference is the Additional Gain for Scan(AGS).

d) The sum of BRG and AGS is the Reference Gain, (RG). For scanning, add 6dB. That is Scanning Gain (SG) = RG+6.

All scanning is conducted at a sensitivity of SG. All evaluation is conducted at a sensitivity of RG.

8.1.3 Search Phase

Scan the entire surface of the shaft step with a sensitivity of SG dB. This is the Search Phase of the examination.

8.1.4 Partial Range Scans

It may occur that at this scan sensitivity, minor discontinuities in the initial portion of the time-base cause repeated stoppages in the scanning sequence, as each such indication has to be evaluated. It hence is permissible to evaluate only a defined later portion of the time – base, such as 50% to 100% of the step diameter during a first scan ignoring echoes in the range of 0 to 50% of the time-base. Subsequently an additional scan shall be conducted to cover the range ignored earlier. The two ranges shall overlap by approximately 10% of the shaft step diameter. During this second scan, sensitivity need be set not to the high value required to detect a reportable indication at back-wall sound path, but to detect a reportable indication at the end of the effective new test range, i.e. 60%. The time-base may or may not be re-calibrated for the shorter range during this split evaluation, as convenient.

Accordingly each shaft step diameter can be scanned by using one, two or more scans covering the entire range of 0 to 100% of the shaft step diameter, less dead zone.

8.1.5 Evaluation Phase

During scanning whenever an indication above 80% FSH is noticed, evaluate the indication immediately, as described below

a) Adjust the gain to obtain an amplitude of RA from the indication and note the gain as Indication Gain (IG). Note down the metal path (distance from probe) of the indication (IMP). Obtain Gain for Sizing, (GS) by subtracting BRG from IG, i.e., GS = IG – BRG.

b) On the DGS diagram draw a vertical line with IMP as abscissa till it meets the back-wall curve. From this meeting point, mark down again GS downward and mark the spot on the diagram. From the flaw size curves find the size in EFBH. If required, interpolate between curves. This size is the EFBH value of the indication.

c) Evaluate the indication to categorize it as Non-Reportable, Reportable or Unacceptable for purposes of reporting.

8.1.6 Scan and Evaluation Continuation

After the evaluation revert to again SG and continue scanning till the entire shaft step is scanned and all indications recorded as per the two previous paragraphs.

Conduct all the steps outlined above from paragraph 8.1 onwards, on each shaft diameter step, in turn.

8.2 Alternative: Flat Bottom Hole Reference Method

8.2.1 Calibration Blocks

A calibration blocks is required. A sketch of the block is provided in Sketch 1, part of Annexure 1. The block shall be of the same material specification and heat treatment

as applicable to the shaft under examination. Essentially the surface finish on diameter should be similar to that on the shaft, but some variation is permitted.

Prior to machining the block, the raw material shall be subjected to Ultrasonic examination by the DGS method and shall be free of indications exceeding an EFBH value of one-third of the required hole size.

The hole diameter shall be as specified in paragraph 8.3 and shall be of 1% of the Block diameter or 2 mm minimum.

The holes shall be machined truly flat bottomed, preferably by end milling. It is expected that deep holes are not possible and it is permitted to machine steps on the far wall such that further shallow drilling shall suffice, as shown in the sketch.

8.2.2 Block Diameter

A block of diameter "D' Shall be valid for use on shaft steps of diameter range 0.9 D to 1.5 D. Sufficient number of blocks are required to adhere to this requirement. The acceptance shall be based on the actual hole size existing in the block even if a coarser level is acceptable on the 1% basis, i.e., no calculated or other allowance shall be used for compensation.

8.2.3 Time-Base Calibration

8.2.3.1 Time-base Calibration Basis

Mechanically measure the shaft diameter within the higher of 1% or 1 mm accuracy. Select a round figure for the required range such as 0 to 100, 0 to 200, 0 to 300, 0 to 400 or 0 to 1000 mm etc. The range shall be such that the first back-wall echo is located between 60% and 90% of the time-base.

The calibration shall be based on the measured shaft diameter and not a separate block such as a reference block.

8.2.3.2 Time-base Calibration Procedure

Calculate the time-base position for the first back-wall echo. Set the time-base controls such that the second back-wall echo is set to this value, with the first back-wall echo being set to zero. Now, lock all the time-base controls other than Delay. Now use the Delay control to shift the first back-wall echo to the calculated position. The time-base in now calibrated, lock delay also. Confirm calibration from the position of echoes of other smaller diameter shaft steps wherever possible and correct errors if necessary.

8.2.4 Sensitivity Calibration

8.2.4.1 Setting the primary Reference Level

At a suitable gain setting, find out which hole provides the highest response. Set the amplitude of this echo to between 70% FSH and 90 FSH using the gain control. Record the Gain as Reference Gain.

8.2.4.2 Drawing the DAC Curve

In turn, pick up each hole on the calibration block, without changing the Gain. Use the instrument screen as a graph. At the metal path corresponding to the first hole, mark the maximized amplitude of the echo. Repeat this for all the other holes. Draw a smooth line through the points so obtained. This is the Distance Amplitude Correction

(DAC) curve. Use a suitable marking pen which would not damage the screen protector sheet.

8.2.4.3 Scan and Evaluation

Scan at a gain value higher than the above reference gain by 6 dB.

Evaluate any indication above 50% by reducing gain back to the reference level. Evaluate the amplitude of each indication by comparison with the height of the DAC curve at the same metal path as the indication and report it as a percentage of DAC.

8.3 Reporting and Acceptance Levels

8.3.1 When no specific instructions are provided on acceptance levels from the Design or the Indentor, the requirements of the following paragraphs shall apply.[1]

8.3.2 Zoning of shaft for acceptance

(a) Portions of each shaft step outside a core area of third of the step diameter are defined as the Peripheral Zone. However, this Zone includes the core area, for a length equal to the shaft step diameter, at each end of the shaft step.

(b) The core area, of a diameter one third of the finished shaft diameter but excluding a length equal to the diameter of the shaft step on any end, is defined as the Core Zone.

Please refer to Sketch 2, Annexure , which describes the above.

8.3.3 Acceptance Levels for the Peripheral Zone

When using the reference hole method, the acceptance level for the peripheral zone shall be 100% DAC. Any indication above 100% DAC is not acceptable. For the DGS method, the acceptance level in this Zone shall be the EFBH of 1% of the shaft step diameter or 2 mm minimum. The EFBH value shall be rounded off to the nearest 1 mm.

It may be noted that the required sensitivity mentioned in clause 8.1.2(b) for the DGS method or the flat bottom hole sizes specified for the calibration block of clause 8.2.1 shall be 1% of the shaft step diameter, unless otherwise specified in the Purchase Order, Tender Document (if referred to in the Purchase Order) or the shaft drawings approved by NPCIL, subject to a minimum of 2 mm.

8.3.4 Acceptance Levels for the Core Zone

When using the reference hole method, the acceptance level for the Core Zone shall be 200% DAC. Any indication above 200% DAC is not acceptable. 200% DAC shall be used by decreasing the gain by 6 dB for evaluation and using the 100% DAC line as the acceptance line.

For the DGS method, the acceptance level in this Zone shall be the EFBH of 2% of the shaft diameter. The EFBH value shall be rounded off to the nearest 1 mm.

---

[1] In the document requiring examination in accordance with this Procedure, Design or other appropriate personnel may change the acceptance requirements, to suit different applications. This may preferably be by changing the nominal 1% to say ½%, 2%, etc. Additionally, the minimum size of FBH or EFBH, nominal 2 mm, may be changed to a different value, a reduction to 1 mm is recommended in case of shafts of small diameter used in critical applications.

(It may be observed that the acceptance levels in the Core Zone is coarser by a nominal ratio of two.)

8.3.5 Reporting Level

The reporting level shall be 50% of the higher of the two sensitivities, i.e. 50% of that applicable to the non-core areas. This shall be so for evaluation by either the DGS method or by the reference hole DAC method as detailed under clause 8.

8.4 Calibration verification and re-calibration

During any calibration re-check, if the instrument sensitivity (amplitude) is found to have decreased by 2 dB or more, or if the time-base is found to read higher than actual values by more than 2% or more of the full screen range, all results of scans since the previous valid calibration shall be cancelled and the entire portion of the scan since the last valid calibration shall be repeated after a new valid re-calibration.

During this re-check, if the instrument sensitivity is found to have increased by 2 dB or more, or if the time-base is found to read lower than actual values by more than 2% or more of the full screen range, all recorded indications since the previous valid calibration shall be re-examined, re-evaluated and re-recorded after a new valid re-calibration.

9.0 AXIAL SCAN

9.1 Calibration of the Time-Base

The time-base of the instrument shall be set to a round figure of just more than axial length. Specifically for this case if unavoidable, the initial pulse may be used for calibration by being set to zero of the time-base scale.

9.2 Probe Selection

Use the largest diameter, highest frequency probe which can provide the sensitivity required.

9.3 Sensitivity:

The back-wall echo amplitude shall be set between 70% and 90% of FSH.

9.4 Scan

The shaft shall be scanned from both ends. If one or more axial steps have a difference of radius of more than 25 mm, all such flat transverse surfaces shall also be used for scanning.

Machine centres at either end will degrade the test conditions. This is acceptable. However centres should be made of minimum diameter commensurate with good machining practice.

9.5 Evaluation

Echoes more than 50% of back-wall shall be analyzed. Any echo due to diameter steps shall be recorded and otherwise ignored.

9.6 Recording Level

All echoes needing evaluation as per clause 8.3.4 shall be recorded, including specifically, cases of echoes due to geometry.

9.7 Acceptance Level

Any echoes, not attributable to shaft geometry and exceeding the reference amplitude (80% FSH) is not acceptable.

10.0 SCAN FOR GRAIN SIZE VARIATION

This scan shall be done radially using all shaft steps and the following detailed requirements are to be followed on each shaft step individually.

10.1 Scan Progression

For this scan alone, continuous scanning is not required. Scan by point checks, the points being spaced no more than 35 mm apart.

10.2 Time-base Calibration

The time-base calibration requirements are identical to the requirements of 7.1.1.2 except that the full screen range selected may be such that the first back-wall echo is located within the wider range of between 40% and 95% of the time-base.

10.3 Amplitude Calibration

The shaft step shall initially be checked at a few spots and spot selected which yields the maximum echo height of the back-wall echo. At this spot, the instrument gain shall be so set such that the first beck-wall echo has an amplitude between 70% FSH and 90% FSH.

However, if during scanning, the back-wall echo exceeds 100% FSH, the reference should be reset at this spot anew as per clause 9.3 and previously scanned areas shall be re-examined.

10.4 Reporting Level

Any drop of the back-wall echo to 80% of the value set in clause 9.4 shall be recorded.

10.5 Acceptance Level

Any drop of the back-wall echo to 50% of the value set in clause 9.4 is not acceptable.

If any observed reduction of back-wall echo is attributed to variations in surface finish, it shall be permissible to discard the results of test and to re-examine after a light uniform cut is taken all over the particular shaft step; this re-finishing shall not be local.

11.0 REPORTING

11.1 Location of Indications

All reportable or unacceptable indications shall be recorded with reference to a key diagram which gives the position of each indication as axial distance from a reference end, angular distance clockwise from a reference mark (such as keyway), as viewed from the reference end and the radial depth of the indication. The drive end, commonly called “DE” shall be used as the reference end. The reference mark shall be a unique existing stamp or preferably, a special identification provided for the purpose and shall be detailed in the report. Recommended marking is as follows:

A identifying punch mark shall be applied on the Drive End face of the shaft near the periphery. This mark identifies the reference end. Also it identifies the angle reference

line, which is the axial line along all shaft steps, on its outside surface and contained within a plane containing the punch mark.

Subsequently, during manufacture of the shaft, machine the shaft in such a way that the punched end is the Driving End and also such that the punch mark coincides with the Driving End keyway.

11.2 Information Required in the Report

The following indication details are required:

a) Purchase Order Number for the main component, such as motor.

b) Description of main component, such as motor.

c) Serial Number of the shaft in the sequence of shafts fabricated.

d) Serial Number of main component, if this can be decided at the time of examination.

e) Material identification references.

f) Details of Project, Unit and Sl.No. of the main component (such as Kaiga, Unit-2, Moderator Pump No.3)

g) Personnel details, including Qualification Information.

h) Details of each scan are to be recorded separately. As a minimum, for each scan the following information shall be reported

Name of Scan
Date and Time
Instrument: Make and Model; Calibration Status references.
Probe: Make and Model
Couplant descriptions
Recordable Indications
Unacceptable Indications
Reference marking information for reporting.

If no indications of an unacceptable or recordable nature are present, this information shall be clearly stated by a separate written statement.

11.3 Reporting Forms

Report forms meeting the requirements of this Specification are to be prepared prior to the actual examination. The forms should permit efficient, unambiguous and complete recording of all test parameters as well as of test results.

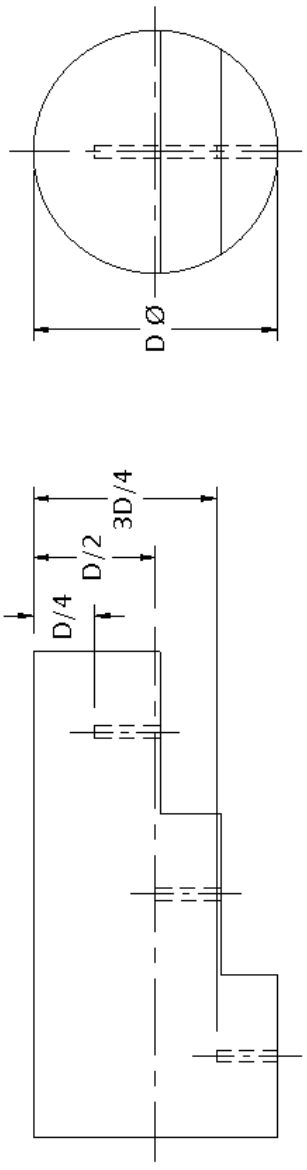
It is recommended that report forms do not include “boxes” from which one or more box shall be selected by tick-marking; instead blank areas shall be provided for entering the information by actual writing-in of information.

While entering information in the report, any errors shall be neatly crossed out, such that the wrong entry is still legible. Corrections shall now be entered and the correction validated by signature.

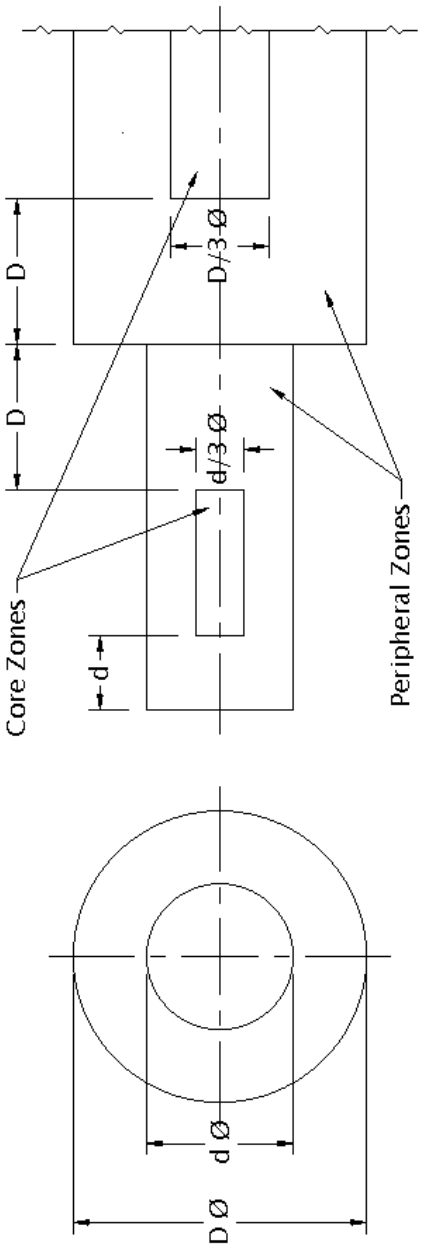
11.4 Documentation

Each page of the report shall be clearly signed and dated. The name and designation of each signatory shall also be provided. Report copies shall be issued to personnel as per the requirements of the Purchase Order.

Annexure 1



Sketch – 1 Flat Bottom Hole Calibration Block



Sketch – 2 Typical Core & Peripheral Zones

ANNEXURE 2

(Appendix 1 to PP-P-1981, Performance Checks of UT Instrument)

A. SCOPE

This Appendix describes the procedures to be followed and provides the requirements to be met to check and confirm that an ultrasonic test instrument is performing adequately, if such a check is required by a Specification or Procedure.

In using the following directions, indications may need to be maintained on the screen over a length of time, with assurance that there is no change in received echo energy. An immersion fixture with an immersion probe can be very convenient for maintaining this constancy over this period. However, use of such a fixture is not mandatory, though then, care has to be taken that changes do not take place and a recheck shall particularly be done with the old control settings.

If the performance of the instrument does not meet the requirements, it shall be serviced and all performance parameters re-evaluated. Such servicing is not within the purview of UT personnel, but must be conducted by the manufacturer, their authorized agents or other electronic servicing personnel of adequate electronic capability.

B. AMPLITUDE LINEARITY

This parameter is also called “Screen Height Linearity”.

Use any convenient angle probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up two simultaneous indications from ½ and 3/4T side drilled holes in a test piece or block which can adjusted such as to provide a ratio of 1:2 between indication heights. from any convenient test piece or block which can adjusted such as to provide a ratio of 1:2 between indication heights. That is, one echo must be twice the height of the other. It is immaterial which echo appears first on the time-base.

In order to obtain this condition, one method is to obtain a stepped block (i.e. one with two distinct thicknesses) and scan it from the un-stepped flat side. On scanning the zone of thickness change, two echoes, backwall echoes from the two thicknesses, will be obtained. By selecting an appropriate probe position, the two echoes can be set at any amplitude ratio to each other, in this case, 1:2 or 2:1. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of the bigger of the two echoes to 80 % full-screen-height.

Without permitting probe movement, re-adjust any of the above controls to change the amplitude of the larger of the two echoes successively from 100 % to 20 % in steps of 10 % full-screen-height. Record the amplitude of the smaller echo in each case. This value must be within 5 % full-screen-height of half the bigger echo, rounded off to the nearest 1 %.

For example, for the case of the bigger echo being at 60 %, the smaller echo must be within the range of 30 % full-screen-height, ± 5 % .

Values outside these call for instrument servicing.

C. AMPLITUDE CONTROL LINEARITY

Use any convenient angle probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up any indication from 1/2T side drilled hole in any convenient test piece or block which can readily be picked by the probe and readily be maintained stable. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of this echo to 80 % full-screen-height. Only the Gain control or controls shall be adjusted further. Without permitting probe movement, change the Gain by ± 6 dB and ± 12 dB and record the amplitudes.

The table below gives the requirements:

Initial amplitude set at % of full screen	Gain Control Change	Acceptance Limits of Amplitude % of full Screen
80 %	- 6 dB	32to 48 %
80 %	- 12 dB	16 to 24 %
40 %	+ 6 dB	64 to 96 %
20 %	+ 12 dB	64 to 96 %

The settings and readings shall be estimated to the nearest 1% of full screen

This check shall be done starting with many representative values of Gain, such that the performance of the Gain control system is evaluated over the entire range of gain control. Where more than one calibrated Gain control is available, such as two separate knobs, each of them shall be checked over their range of control. In order to check the gain controls at various ranges, other controls such as Damping and Filter may be set at different combinations at the start of each test sequence of varying the Gain by ± 6 and ± 12 dB.

The values of 6 and 12 dB may be obtained by combining two of the controls.

When not using the DGS method, depending on the application, it may be adequate to limit the check to the general range of values in use during actual scans.

D. INSTRUMENT TIME -BASE LINEARITY

This parameter shall be checked at or near range values corresponding to those normally in use.

In the following descriptions, the percentage values refer to the time-base, 0 % and 100 % being the left and right hand extreme graduations.

Select a block of uniform thickness of approximately one-fifth of the range to be checked. Use any convenient normal beam probe, and suitable settings for control settings other than those related to the time-base. Calibrate the instrument time-base to five times this thickness, by positioning the second back-wall echo to 40 % and third back-wall echo to 60 % of the screen. This would require adjustments to the Range, Material Calibration and Delay controls or their equivalent. Lock all of these controls other than Delay.

Using Delay, shift the second back-wall echo to a selected screen division and record the position of the next echo, i.e. the third back-wall echo. Selected screen divisions, in turn, shall be zero, 20 %, 40 % and 80 %. The expected reading shall, in each case be obviously 20 % larger than the selected screen division.

In each case the permissible error from expected reading shall be within 2 % of the time-base. In instruments with a total of 50 divisions for the time-base, this will correspond to one such small division.

In many instruments, the display does not extend beyond the final time-base mark. In such cases, the check of the last point shall be done in reverse, by shifting the third back-wall echo to the last mark and reading the position of the second back-wall echo.

Specifically in the case of the initial or last portions of the time-base twice the error of 2 %, i.e. 4 % may be permitted. This however, is conditional on checks of the 5 to 25 % or the 75 to 95 % or both respectively, additionally being done and the results being within 2 %, (in instruments with 2% as the small division size, these values may be changed to 6 to 26 % and 76 to 96 % respectively).

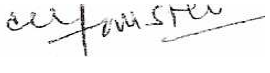
NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

PROCEDURE NO.: PP-P-2013 REV. NO. 2

TITLE	PROCEDURE FOR ULTRASONIC EXAMINATION OF STEEL CASTINGS FOR GENERAL PURPOSE

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	NAME	**SIGNATURE**	**DATE**
PREPARED BY	S.S. Som SSE(QA) KAPS	Sd/-	March 2001
REVIEWED BY	M. Mohan Babu, ACE (ISI)		March 2001
APPROVED BY	C. Awasthi, ED (QA)		March 2001

REVISION CONTROL SHEET

PROCEDURE

NO.: PP-P-2013 REV. NO. 2

PROCEDURE FOR ULTRASONIC EXAMINATION OF STEEL CASTINGS FOR GENERAL PURPOSE

Rev. No. & date	Description of Revision	Revised By	Reviewed By	Approved By
1 May 2007	Editorial changes and changes as per latest codes/ standards	P.V. Khambatkone CE (QA) A.K. Palit, CE(QA)	M. Mohan Babu CE (ISIS), QA	M. Mohan Babu CE (ISIS), QA
2 Feb. 2013	Editorial changes and changes as per latest codes/ standards	A. K. Palit, CE (QA)	A. K. Palit CE (QA)	K. P. Dwivedi ED (QA)

1.0 SCOPE

This procedure describes the requirements for ultrasonic examination of steel castings, by pulse-echo, manual contact method.

2.0 REFERENCES

This procedure is based on the following:

a) ASME Section V, Article V, 2010 Edition.
b) ASME Section III, Subsection NB, 2010 Edition.
c) ASTM A-609 Standard Specification for Longitudinal Beam Ultrasonic Inspection Carbon and Low Alloy Steel Castings.
d) PP-P-1981 Rev.2 General Requirements & Formats for Ultrasonic examination procedure.

3.0 SCAN DIRECTIONS

A normal beam scan using longitudinal waves shall be conducted. The ultrasonic beam shall be introduced perpendicular to the test surface.

4.0 ULTRASONIC INSTRUMENT

4.1 Pulse-echo type instruments shall be used. The amplitude linearity, amplitude control linearity and time base linearity shall meet the requirements defined in Annexure 3.

These parameters shall be checked at the time of commencement of the examination unless valid records less than six months old exist proving conformance and no repair of instrument has been necessitated since. Witnessing personnel may call for rechecks of these parameters at the start of examination or at any time during examination, if there is reason to doubt instrument performance in these regards.

List of UT instruments include following:

Sl.	Models	Models
1	M/s. Roop Ultrasonix, India.	4400, 440A, 4400M
2	M/s. Electronic and Engineering Co., India	ESM-2, 2M, EX-10,100
3	M/s Modsonic	Einstein
4	M/s. Krautkramer, Germany, USA	USIP11, USD10, USL 48
5	M/s. Karl Deutsch, Germany	1023, 1024, 1025, 1030
6	M/s. Panametrics, USA.	Epoch-2000, Epoch-II
7	M/s. Sonic, USA.	FTS MK-I, FTS MK-IV

However, Head QA / Supdt. QA of applicable unit shall have the authority to permit use of any other equipment which meets the requirements of Annexure 3.

4.2 Probes

Probes shall conform the following requirements:

Size: Transducers having 25 mm diameter or 25 mm x 25 mm square crystal shall be used.

Frequency: Probes of 2 to 5 MHz shall be used.

5.0 PERSONNEL QUALIFICATION

Personnel conducting the ultrasonic examination in accordance with this specification shall be qualified to level-II or level-II (ISNT/ASNT). Personnel evaluating the ultrasonic examination shall be qualified to level-II or level-III (ISNT/ASNT). However, Head QA / Supdt.QA of the unit may conduct additional evaluation tests to ensure theoretical and practical competence including site specific aspects.

6.0 GENERAL REQUIREMENTS

6.1 Surface Conditions

The surface of the castings to be examined shall be free of loose scale, paint, dirt etc. The surface roughness of scanning surfaces shall not exceed 6.35 μm.

6.2 Couplant

The couplant shall be oil of adequate viscosity to permit scanning without frequent reapplications.

6.3 Scanning Speed

The maximum rate of probe (normal beam search unit) movement shall be established by moving the probe on the calibration block for which the amplitude from reflector FBH shall be at least 50% of the PLR. However the scanning speed shall not exceed 150 mm / sec.

6.4 Probe Overlap

To assure complete coverage of the castings volume, the overlap shall be at least 10% of the probe diameter.

6.5 Calibration Identity and Validity

Any change of instrument or control settings (other than temporary changes of controls which operate on fixed steps), probe, couplant or probe cables shall require re-calibration. Operating variables including the test instrument, its control settings, its power source, probe, probe cable and couplant shall be unchanged once calibrated throughout scanning and evaluation, except for readjustments of gain between evaluation and scan as required during examination. After initial calibration, rechecks the proper functioning of the equipment shall be checked by the use of the reference specimens, as a minimum:

a) At the beginning of each production run of a given size and thickness of the given material.

b) After each 4 hours or less during production run.

c) At the end of the production run.

d) Any time when the malfunction of the equipment is suspected.

6.6 Reject

This control is also called "suppression" in some instruments and shall be maintained in the minimum position (or OFF position, if available) throughout the examination.

6.7 Continuously Variable Controls

Continuously variable controls such as damping and continuously variable gain shall be maintained at either of the extremes of their positions to the extent possible to avoid inadvertent changes.

7.0 PRIMARY SCAN

7.1 Calibration Blocks

Calibration blocks shall be of the same material specification and heat treatment as applicable to the test object. The surface finish at the entry surface of the calibration block should be similar to that of the test object. Prior to machining the block, the raw material shall be ultrasonic examination checked and shall be adequately defect free.

The hole diameter shall be 3% of the thickness with a minimum of 3 mm. The holes shall be machined truly flat bottomed, preferably by end milling.

The diameter of the calibration blocks and block length shall be as shown in the Annexure 2.

7.2 Time Base Calibration Basis

Mechanically measure the test object diameter or thickness as applicable within 1 mm accuracy. Select a round figure for the required range such as 0 to 50, 0 to 100 or 0 to 200 mm etc. the range shall be such that the first back wall echo is between 60% and 90% of the time-base. Calibration on reference block such as V1 block is accepted for the cases where job configuration does not give back wall echo.

7.3 Time Base Calibration Procedure

Calculate the time base position for the first back wall echo. Set the time base controls such that the second back wall echo is set to this value, with the first back wall echo being set to zero. Now, lock all the time base controls other than delay. From this setting, use the delay control to shift the first back wall echo to the calculated position. The time base is now calibrated, lock delay also. Confirm calibration from the position of echoes of other smaller diameter / thickness area wherever possible and correct any errors if necessary.

7.4 Sensitivity Calibration

7.4.1 Setting the primary reference level

At a suitable gain setting find out which hole provides the highest response. Set the amplitude of this echo to between 70% FSH and 80% FSH using the gain control. This is the reference gain and should not be changed.

7.4.2 Drawing the DAC curve

Use the instrument screen as a graph. At the metal path corresponding to the first hole (which gives highest response), mark the maximized amplitude of the echo. Repeat this for all the other holes. Draw a smooth line through the points so obtained. This is

the distance amplitude correction (DAC) curve. Use a suitable marking pen which should not damage the screen protection sheet.

7.5 Scanning, Recording & Evaluation

Scan at a gain value higher than the above reference gain by 6 dB. Evaluation shall be done at reference gain. Evaluate indications which:

a) whose amplitude equals or exceeds 50% of the established DAC curve,

b) produces indications accompanied by 20% loss of back reflection not associated with or attributable to the geometric configuration.

7.6 Acceptance Level

a) Indications which are mentioned in (b) in the clause 7.6 with reduction in back reflection exceeding 50% not associated with geometric configuration are unacceptable.

b) Areas giving indications exceeding the amplitude reference line with any dimension longer than those specified in the following tabulation are unacceptable:

Quality levels shall apply for casting thicknesses as mentioned below-

a) Quality level 1 for thickness up to 50 mm.

b) Quality level 3 for thickness 50 mm to 100 mm.

c) Quality level 4 for thickness greater than 100 mm.

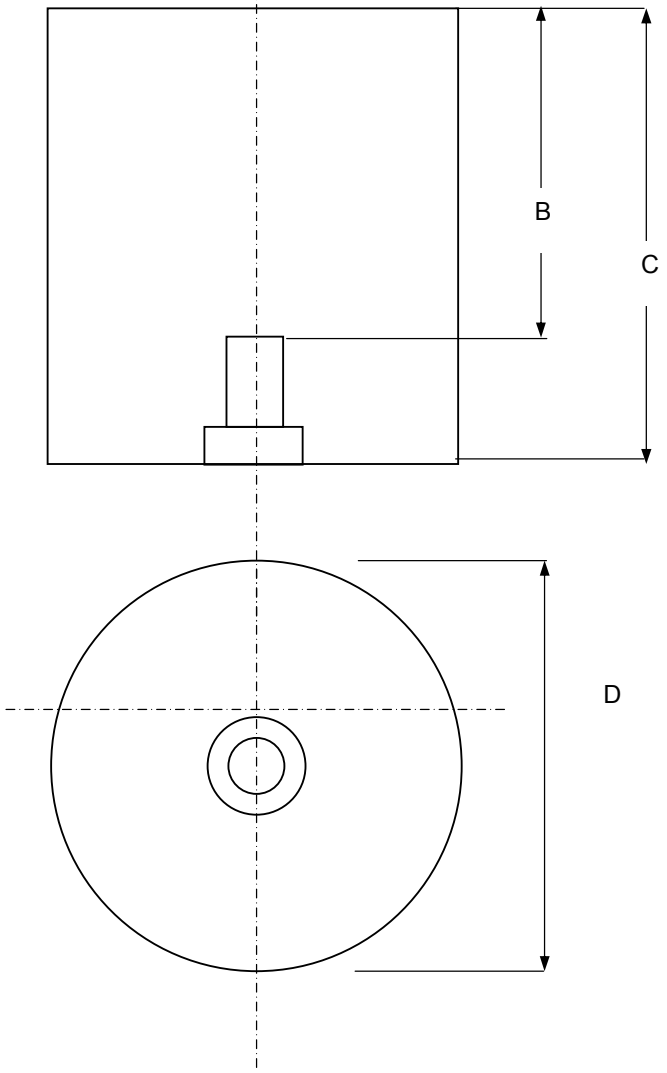
UT Quality Level	Longest Dimension of Area
1	38 mm
2	50 mm
3	64 mm
4	75 mm

Longest dimension of area refers to the surface area on the casting over which continuous indication exceeding the transfer corrected DAC is maintained.

Annexure 1

ULTRASONIC EXAMINATATION REPORT			
REPORT NO.:.		DATE OF TESTING :	
REFERENCE PROCEDURE NO.:		WORK ORDER NO. :	
REFERENCE CODE NO.:			
MATERIAL DESCRIPTION			
MATERIAL :		DIMENSIONS:	
IDENTIFICATION:		SURFACE CONDITION: AS CAST/PROOF MACHINED/GROUND	
INSTRUMENT DESCRIPTION			
INSTRUMENT USED :	MACHINE No.:	MAKE:	
SEARCH UNIT :		COUPLANT : OIL / WATER	
CALIBRATION			
RANGE CALIBRATION:			
CALIBRATION : STANDARD		SENSITIVITY:	
METHOD & TECHNIQUE:			
EXAMINATION			
SCANNING:			
EXAMINATION STARTED AT : HRS.		CLOSED AT : HRS	
CALIBRATION RECHECKED AT	1. Hrs	2. Hrs	3. Hrs
OBSERVATION OF RECALIBRATION CHECK	1.	2.	3.
OBSERVATION :			
EVALUATION :			

Annexure 2



STANDARD REFERENCE BLOCK

(For Axial Scanning)

Note: For Radial Scanning, the hole should be drilled radially on the circumference of the Reference Block.

DIMENSIONS OF REFERENCE BLOCKS

Hole Diameter In mm	Metal Distance 'B' (mm)	Overall Length 'C' (mm)	Diameter 'D' (mm)
3	25	45	50
3	50	70	50
3	75	95	50
3	150	172	75
3	250	273	100
3	B	B+ 19	125

NOTE 'B' FOR ADDITIONAL SUPPLEMENTAL BLOCKS FOR THICKNESS > 250mm.

ANNEXURE 3

(Appendix 1 to PP-P-1981, Performance Checks of UT Instrument)

A. SCOPE

This Appendix describes the procedures to be followed and provides the requirements to be met to check and confirm that an ultrasonic test instrument is performing adequately, if such a check is required by a Specification or Procedure.

In using the following directions, indications may need to be maintained on the screen over a length of time, with assurance that there is no change in received echo energy. An immersion fixture with an immersion probe can be very convenient for maintaining this constancy over this period. However, use of such a fixture is not mandatory, though then, care has to be taken that changes do not take place and a recheck shall particularly be done with the old control settings.

If the performance of the instrument does not meet the requirements, it shall be serviced and all performance parameters re-evaluated. Such servicing is not within the purview of UT personnel, but must be conducted by the manufacturer, their authorized agents or other electronic servicing personnel of adequate electronic capability.

B. AMPLITUDE LINEARITY

This parameter is also called “Screen Height Linearity”.

Use any convenient angle probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up any two simultaneous indications from ½ and 3/4T side drilled holes in any convenient test piece or block which can adjusted such as to provide a ratio of 1:2 between indication heights. That is, one echo must be twice the height of the other. It is immaterial which echo appears first on the time-base.

In order to obtain this condition, one method is to obtain a stepped block (i.e. one with two distinct thicknesses) and scan it from the un-stepped flat side. On scanning the zone of thickness change, two echoes, backwall echoes from the two thicknesses, will be obtained. By selecting an appropriate probe position, the two echoes can be set at any amplitude ratio to each other, in this case, 1:2 or 2:1. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of the bigger of the two echoes to 80 % full-screen-height.

Without permitting probe movement, re-adjust any of the above controls to change the amplitude of the larger of the two echoes successively from 100 % to 20 % in steps of 10 % full-screen-height. Record the amplitude of the smaller echo in each case. This value must be within 5 % full-screen-height of half the bigger echo, rounded off to the nearest 1 %.

For example, for the case of the bigger echo being at 60 %, the smaller echo must be within the range of 30 % full-screen-height, ± 5 % .

Values outside these call for instrument servicing.

C. AMPLITUDE CONTROL LINEARITY

Use any convenient angle beam probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up any indication from 1/2T side drilled hole in any convenient test piece or block which can readily be picked by the probe and be maintained stable. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of this echo to 80 % full-screen-height. Only the Gain control or controls shall be adjusted further. Without permitting probe movement, change the Gain by ± 6 dB and ± 12 dB and record the amplitudes.

The table below gives the requirements:

Initial amplitude set at % of full screen	Gain Control Change	Acceptance Limits of Amplitude % of full Screen
80 %	- 6 dB	32 to 48 %
80 %	- 12 dB	16 to 24 %
40 %	+ 6 dB	64 to 96 %
20 %	+ 12 dB	64 to 96 %

The settings and readings shall be estimated to the nearest 1% of full screen

This check shall be done starting with many representative values of Gain, such that the performance of the Gain control system is evaluated over the entire range of gain control. Where more than one calibrated Gain control is available, such as two separate knobs, each of them shall be checked over their range of control. In order to check the gain controls at various ranges, other controls such as Damping and Filter may be set at different combinations at the start of each test sequence of varying the Gain by ± 6 and ± 12 dB.

The values of 6 and 12 dB may be obtained by combining two of the controls.

When not using the DGS method, depending on the application, it may be adequate to limit the check to the general range of values in use during actual scans.

D. INSTRUMENT TIME -BASE LINEARITY

This parameter shall be checked at or near range values corresponding to those normally in use.

In the following descriptions, the percentage values refer to the time-base, 0 % and 100 % being the left and right hand extreme graduations.

Select a block of uniform thickness of approximately one-fifth of the range to be checked. Use any convenient normal beam probe, and suitable settings for control settings other than those related to the time-base. Calibrate the instrument time-base

to five times this thickness, by positioning the second back-wall echo to 40 % and third back-wall echo to 60 % of the screen. This would require adjustments to the Range, Material Calibration and Delay controls or their equivalent. Lock all of these controls other than Delay.

Using Delay, shift the second back-wall echo to a selected screen division and record the position of the next echo, i.e. the third back-wall echo. Selected screen divisions, in turn, shall be zero, 20 %, 40 % and 80 %. The expected reading shall, in each case be obviously 20 % larger than the selected screen division.

In each case the permissible error from expected reading shall be within 2 % of the time-base. In instruments with a total of 50 divisions for the time-base, this will correspond to one such small division.

In many instruments, the display does not extend beyond the final time-base mark. In such cases, the check of the last point shall be done in reverse, by shifting the third back-wall echo to the last mark and reading the position of the second back-wall echo.

Specifically in the case of the initial or last portions of the time-base twice the error of 2 %, i.e. 4 % may be permitted. This however, is conditional on checks of the 5 to 25 % or the 75 to 95 % or both respectively, additionally being done and the results being within 2 %, (in instruments with 2% as the small division size, these values may be changed to 6 to 26 % and 76 to 96 % respectively).

NUCLEAR POWER CORPORATION OF INDIA LIMITED

(A Govt. of India Enterprise)

DIRECTORATE OF QUALITY ASSURANCE

DOCUMENT NO.: QAD-NDT-PROC-UT-10/ Rev.3

TITLE	PROCEDURE FOR PRE-SERVICE AND IN-SERVICE ULTRASONIC THICKNESS GAUGING OF PIPING COMPONENTS FOR SURVEY OF EROSION OR CORROSION

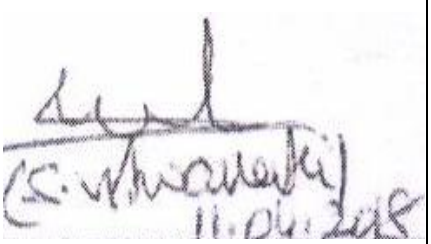
This procedure can be used as reference procedure. A "Technique Sheet/Job specific procedure" is to be prepared identifying the NDT process variables and identifying "Acceptance Criteria" (NPCIL Specification / Code clause) for a given application by the User/Vendor.

REVISION NO.	0	1	**2**	**3**
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REVISION CONTROL SHEET

PROCEDURE FOR PRE-SERVICE AND IN-SERVICE ULTRASONIC THICKNESS GAUGING OF PIPING COMPONENTS FOR SURVEY OF EROSION OR CORROSION

DOCUMENT NO.: QAD-NDT-PROC-UT-10/ Rev.3

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1.0 PURPOSE

This procedure describes ultrasonic thickness measurements of piping components, such as pipes and elbows, for survey of corrosion or erosion. This procedure is applicable to Secondary Systems of the power plant and to PHT feeders.

2.0 SCOPE

For PHT Feeders, Annexure 1 provides details of measurement locations. Information of which or all feeders that require measurement shall be as directed by NPCIL Design at Headquarters. For PSI, all locations shall be measured in all feeders.

For the Secondary Systems(Annexure-3), the components to be subjected to measurement and the extent of the measurement (such as grid spacing), shall be as per HQI -0543(Guideline for implementation of periodic inspection programme of mitigation of FAC) issued by Directorate of Operations.

This Procedure may also be applied to piping components of any other system if so directed by the applicable Design Group.

3.0 REFERENCE DOCUMENTS

a) ASME-B & PV Code Section –V Article 23-SE-797-2017 issue

b) HQI No. 0543 Revision 01- 2013 issue-FAC in Secondary Cycle Piping

4.0 PERSONNEL QUALIFICATION

Personnel who perform thickness measurements according to this Procedure shall be qualified to Level I or above, from the ISNT or the ASNT.

Personnel who perform equipment set-up and calibrations according to this Procedure shall be qualified to Level II or above, from the ISNT or the ASNT. They shall also be responsible for supervision of the measurement tasks and for evaluating the results. The evaluation shall include a comparison with previous measurement records.

Personnel should be individually checked and certified in writing for competence by the applicable Site or Station, in accordance with their written Procedure, prior to their performing measurements.

5.0 INSTRUMENT & PROBES

IMPORTANT

Most ultrasonic thickness measurement systems can under certain difficult conditions, read twice the actual thickness (rarely, even three times). Considering this and other factors, it is to be ensured that the probe-instrument combination is capable of measuring the lowest thickness expected conservatively, without error. Generally use moderate probe sizes for quicker readings, especially for PHT Feeders where personnel radiation exposure is an important consideration. However, where erratic or inconsistent readings are obtained, use a smaller probe which is certain to produce correct readings even though greater care and time is needed.

The erosion process of FAC (Flow-Assisted Corrosion) can occasionally result in pits and grooves on the inside, which may be tapered or sharp sided. Hence, do not ignore unexpected low readings as irrelevant without properly calibrated repeated measurements with smaller probes or other measurement systems, and a thorough analysis.

5.1 Instruments:

Any ultrasonic thickness instrument operating on the twin-crystal pulse echo principle shall be used, subject to a satisfactory calibration as described later. The instrument shall operate at frequencies from 2 to 10 MHz or more and shall have a measuring range of 1.2 mm to 100 mm or better. It shall have a measuring accuracy of ± 0.01 mm.

Some of the instruments applicable are listed below. It is preferable to use instruments which show a UT A-Scan trace, such as the Panametrics instrument. This following list is not restrictive.

a) M/s GE (Krautkrämer), Models DM, DM2, DM3, DM4, DM5E, DM5EDL, CL5 and their variants

b) M/s Panametrics, U.S.A., Model 37 and variants such as 37 DL PLUS, 38 DL PLUS when used with dual-crystal probes only.

c) M/s Modsonic, India, Model Edison 1-P and WAVE series (made in U.S.A.)EHC-09DLCW and their variants

d) M/s EEC Make, ETM-3

5.2 For selection of probes:

a) Generally, by actual trial, select a probe from those available such that, without undue effort or time, it provides the most stable readings. Within this limitation, use the highest frequency available.

b) For use on pipes, any probe up to a maximum of 12 mm φ may be used. For elbows, other components with curvature in two planes, and PHT Feeders, probe size is restricted to 5 mm φ maximum.

c) Even though special probes with curved delay blocks to suit job curvature are available, this Procedure does not cover their usage; it is restricted to probes with flat contact surfaces. Do not reshape dual probe delay blocks.

d) With respect to the area to be measured, consider the size of the probe. For example, while measuring PHT Feeders, total probe height of the probe shall be restricted because of the close spacing of feeder components.

e) For measurements on painted surfaces, if special probes, compatible with the instrument, are available, which cancels out errors due to the paint layer, such probes are preferred.

f) A further requirement for additional measurements with a smaller probe is provided, in "Measurement Method".

6.0 CALIBRATION

Primarily, calibration shall be conducted in accordance with the instructions provided in the Instruction Manual of the specific instrument in use. However, the following aspects also apply:

a) Identify from the Instruction Manual whether the instrument uses built-in V-Path Correction. If so, use only probes supplied by the manufacturer of the instrument.

b) Using the Set-Up Program of the instrument, according to the Manual, identify the probe type to the instrument. If the Manual indicates that the instrument automatically identifies the probe, omit this step and instead, verify using instructions from the Manual that the instrument has correctly identified the probe; override if incorrect.

c) For measurements on painted surfaces, if special probes compatible with the instrument are available, which cancels out errors due to the paint layer, such probes are preferred.

d) For other than PHT Feeders, calibrate using standard thickness reference blocks supplied with the instrument, preferably the block(s) attached to the instrument. If any component has sharp single or dual curvature, consider the detailed calibration steps below for PHT feeders.

e) For PHT Feeders, other than for a preliminary calibration step, do not calibrate the instrument using the calibration reference samples supplied with the instrument. Calibrate using actual samples of the component to be checked, such that the sample is of the same raw material specification and product type (forging etc.), according to the following:

f) For pipes, a sample or a portion shall be machined or ground, on the inside surface, such that the ground surface is parallel to the outside surface. The resulting thickness value shall preferably be less than half the original un-ground value and shall at least be well below the smallest value conservatively expected to be encountered in the field. Use this sample for the thin reference and an un-ground sample for the thick reference.

g) For elbows, follow the same procedure as above. Additionally, both the references shall be at the extrados, and may be at either end of the sample elbow.[1]

h) Mechanically measure, to an accuracy of at least 0.02 mm, the thickness of the two references above. Use a measurement tool not subject to error from the curvature of the inside surface, such as a ball ended micrometer, with the ball end contacting the more concave end of the measurement, the inside. Use a double ball end micrometer if essential. Record the measurements. The reference pieces shall be marked by paint at the outline of the area where the thickness is sufficiently uniform. The pieces shall also be uniquely numbered for identification and be maintained at the Station, with the authenticated record of their mechanical measurement.

i) According to the instructions in the Instruction Manual, using these two thickness references, calibrate the instrument.[2] (Refer to instructions in "Measurement Method"). Record the parameters **Velocity** and **Delay (or Probe Delay)** of the instrument, as calibrated. If the instrument in use does not output these parameters, this must be explicitly stated in the report.[3]

j) In the cases of components with dual curvature, from the calibration samples, determine if full coverage is not possible and record the limitations in the Calibration Record. For example, for elbows, it may not be possible to obtain readings along the intrados extreme and adjacent points.

k) Repeat calibration every 4 hours. In the case of PHT Feeders, repeat calibration every 2 hours or after every 10 feeders, whichever occurs earlier.

7.0 PRECAUTIONS

Before commencing thickness measurements, any thermal insulation shall be removed and the surface shall be cleaned to remove dust or dirt. Any non-adherent scale or paint shall also be removed. If paint thickness is estimated or measured to be likely to cause significant error, the paint shall be removed in any case. Sample measurements may be taken to ascertain the error due to paint, by measuring at a few locations

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[1] Due to the presence of a layer of couplant, an error will be present even with this calibration procedure, for measurements on elbows at other than along the extreme extrados line. This is felt to be small and is ignored.

[2] Some instruments require that the probe be first cleaned, left uncoupled to any object and a specific control be operated, so that the instrument may identify the length of the delay blocks of the probe.
Subsequently, the two samples are measured and their measured thickness identified by the instrument according to Manual instructions. Usually, the thin sample is used with the instrument's Delay key and the thick one for the Velocity key, even though the calculation of these two parameters requires both inputs.

[3] If the instrument does not have built-in V-path correction, upon conducting a correct calibration, the velocity setting of the instrument will have a value somewhat larger than the actual velocity of sound in the test material, particularly for small thickness ranges. This is not an error.

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where the paint appears thickest visually. Compare with readings at the same spots after removing the paint.

If measurements are being done for the first time, the job shall be identified by paint at each location requiring measurements. The paint shall be such that it shall not be degraded or obliterated in service, particularly, it shall be temperature resistant. It should not be deleterious to the job; e.g., for stainless steels, requirements such as limits in halogen or sulphur content shall be met.

For any subsequent measurements, over a period of time, check that the previous markings are legible and that they are not likely to be obliterated during the current measurements. If required, renew the markings.

Ensure that the identification paint is of negligible thickness.

The marks shall be identified by lettering and numbering, using similar paint, such that each of the points can be uniquely identified. Each point need not be numbered, but the optimum number of identifying markings shall be made to ensure quick, error-free identification of a location, without clutter.

Paint marking may be impossible and is of no use where measurement spots are out of view. Practically, this limitation is unavoidable with manual measurement. The Report shall detail these locations.

8.0 EXAMINATION

8.10 PREREQUISITES

8.10.1 COUPLANT:

Machine oil, grease or any mixture of these may be used as couplant.Where suitable, water may also be used. In general, more viscous couplants are required for non-horizontal surfaces or for rough surfaces.

8.10.2 CALIBRATION IDENTITY:

Recalibration is required if any change is required is necessary in the following:

a) Instrument
b) Probe
c) Probe Cable

A change in couplant does not require recalibration, for thickness measurement. However, it may be advisable to confirm accuracy of calibration with the couplants likely to be in use.

8.10.3 PREPARATION

For each measurement:

a) For each component to be measured, obtain the value of nominal thickness (T_{nom}).
b) Check whether the job is too hot to touch. If so, postpone measurements till the job is cooled.
c) Apply couplant on the surface to be measured.

d) Place the probe on the material surface firmly and with consistent, moderate pressure.

e) Ensure that the probe is placed at the measurement spot painted.

f) The probe shall be oriented such that the delay block separator of the twin-crystal probe is circumferential to the sharper curvature. *For example, on pipes, this separator line shall be at right angles to the pipe axis*. Remember the orientation.[4]

g) Establish probe perpendicularity with respect to the surface of the material. On curved surfaces, rock the coupled probe back and forth along the curvature of the material surface and watch the accompanying increase and decrease in the thickness readings. Take the lowest reading as this reading represents probe perpendicularity.

h) If an A-Scan display is available, look for a proper presentation in this display, identifiable with experience, prior to accepting the reading. Do check if due to unusually low thickness, improper contact or poor coupling conditions, the instrument is reading a multiple of the thickness.

i) Take readings at each of the locations specified, in accordance with the requirements. Ensure that the reading noted down applies to the location.

j) In addition to the readings at specified locations, locate the minimum thickness of the component, by taking closely spaced measurements at and around areas of low thickness. Record this single value of lowest thickness separately, identifying its position to nearest available reference or references.

k) In addition to mention in the tabulated data reports, it is recommended to prepare a separate list of non-measurable locations, with reasons why measurement is not possible, such as limitations of this Procedure on sharp concave curvature, or obstruction to probe or inability to reach the measurement spot. Similarly, also report points where paint marking is not possible.

l) In case low thicknesses below T_{nom} (below $0.875 \times T_{nom}$) are noted, review the measurement method. Measure with a system capable of much lower thicknesses, such as use of a probe of very small size (such as the Krautkrämer DA312B16 of 3 mm φ) with an appropriate Thickness Instrument calibrated on low thickness according to this Procedure. Re-measure thickness over the entire component and obtain sample measurements of similar components to extend the measurements with low thickness measurement capability over all areas necessary in a conservative manner.

m) Prevent ingress of couplant, particularly oil or grease, into crevices or other areas, where they may be difficult to remove later and may become a fire or smoke hazard. Nevertheless, in case such spillage or percolation happens, report the occurrence.

Probes with side cable exit are preferred and for such probes, this exit direction provides a convenient reference.

9.0 ACCEPTANCE

Prima facie, if the set of measured thickness value has any value below $0.875 \times T_{nom}$, where T_{nom} is its nominal thickness, it is not acceptable. However, the applicable Design Group, to whom the data is reported, shall decide final acceptance and life assessment of components may be calculated as per ANNEXURE-6 of HQI 0543.

10.0 POST-MEASUREMENT CLEANING

After completion of measurements, remove couplant from the measuring surface and clean the area so that the components that are measured are fit for being re-insulated.

11.0 REPORTING REQUIREMENTS

i) The following shall apply:

a) The Report shall state this Procedure Number and Revision, the Drawing Number, the Line Number, the component description (e.g., "Pipe") and its identification, its descriptive location, its nominal diameter and nominal thickness (T_{Nom}).

b) The Report shall provide the measured thickness values in a Tabular Format, with each thickness value being entered at the correct place in the matrix of locations of a developed view of the object being measured. The data shall be provided to the applicable Design Group at Headquarters to enable them to evaluate adequacy. Additionally, if required, the data record shall be provided in a computerised form for convenience in automated evaluation.

c) For both forms of report above, any readings of thickness that are below T_{Nom} shall be highlighted suitably or reported separately.

d) Similarly, further emphasise, any readings of thickness that are below $0.875 \times T_{Nom}$.

e) Include the minimum thickness located.

ii) In addition to the Data Report to the applicable Design group at Headquarters, the Report shall include the following information:

a) Instrument: Make, Model, Serial Number

b) Probe: Make, Model, Type, Size, Frequency, Serial Number (if available)

c) Probe Cable: Make, Model, Type, Length, Instrument Connectors, Probe Connectors

d) Couplant or couplants

e) Calibration data including paired values of calibration measurement with respect to its mechanically measured value, ultrasonic instrument parameter values, calibration block identification details

f) Signature with Name, Designation and Company of each person performing each calibration and set of measurements, with supervisory signatures and UT qualifications.

Annexure 1

Measurement Locations for PHT System Feeders in the Vicinity of End Fittings

The attached sketch "PHT Feeder Measurement Locations" shows a schematic view of a typical feeder (Annexure 2).

1 In the figure, locations A to H describe axial locations as follows:

A - Grayloc Hub, adjacent to weld to elbow.

B - First Elbow, adjacent to Weld with Grayloc Hub

C - Midpoint of First Elbow

D - First Elbow, adjacent to weld to Second Elbow, Stub Pipe if present, or Feeder

E - Second Elbow, adjacent to weld to First Elbow, or Stub Pipe if present

F - Midpoint of Second Elbow

G - Second Elbow, adjacent to weld to Feeder Pipe

H - Feeder Pipe

2 Please note the following aspects of the figure:

a. The sketch is a schematic; generally, most elbows are less than the 90° shown, the second elbow is not present in many cases (the First Elbow is directly welded to the Feeder), elbows are generally less than 90° and the Stub Pipe is present in only a very few cases.

b. For the First Elbow, 0° is to be taken as at its extrados extreme. This reference shall also apply to the Grayloc Hub and to the Stub Pipe if present. Similarly, for the Second Elbow, 0° is to be taken as at its extrados extreme and the feeder pipe shall use the same reference.

c. Readings are required at every 90° around, i.e., at 0° (corresponding to extrados for elbows), 90°, 180° (intrados for elbows) and 270°. Angles increase clockwise when viewing from the end closest to the Grayloc. Please note that the angle notation is not based on flow direction.

3 On the extrados of elbows (0°), measure every 20 mm along the elbow starting from the end closes the Grayloc, and report them in the region of measurement of the sketch, e.g., C1, C2 etc. Enter the data in Table 1 of the attached formats.

4 In addition to these readings, locate the minimum thickness of each elbow at the extrados by taking closely spaced measurements at and around areas of low thickness. Record this single value of lowest thickness separately, identifying its position to nearest available reference or references, in Table 3.

5 On the rest of the locations (90°, 180° and 270°), measure at each of the locations A to G. Enter the data in Table 2.

6 At location H, the Feeder Pipe, measure adjacent to the weld. Additionally, measure every further 20 mm, till the readings are consistently equal to or exceed TNom, all round.

7 If a Stub Pipe is present, record thicknesses on it at three axial positions labelled SP1, SP2 and SP3, where SP1 is adjacent to the weld to the First Elbow and SP3 is adjacent to the weld to the Second Elbow and SP2 is its middle. Enter the data in Table 5.

8 If the measured wall thickness of any of the above readings is smaller than 0.875× TNom, measure at spots all round at intervals 1 hr of clock (30°). Enter the data in Table 4.

9 Report all measurements in Tabular Form as stated above, one sheet for each Feeder, stating the Date of measurement, Unit, Feeder Identification (corresponding Reactor Channel No.), Inlet or Outlet.

10 If measurement is impossible at any location, due to any reason, record “N” in the data Table and state the reason in a footnote to the table. If the item in the Table does not exist for the specific Feeder, such as by a Second Elbow not being present, state this in the space for the entire set of readings applicable.

REPORTING FORMATS FOR PHT FEEDER THICKNESS MEASUREMENTS

Unit: ISI interval: Feeder No.: Inlet/Outlet:
Feeder size (mm NB): T_{Nom} (mm): $0.875 \times T_{Nom}$ (mm):

Observations:

Table 1

Readings at Extrados (0°) from B to H at 20 mm intervals and on Feeder Pipe

Sl.	Axial location		Thickness Values (mm)
	B-C		
	C-D		
	D-E		
	E-F		
	F-G		
	G-H		
	H (straight portion, to the extent possible)	0°	
		90°	
		180°	
		270°	

Table 2

Grid Location Measurements (Thickness Values in mm.)

Sl.	O'clock	A	B	C	D	E	F	G	H
1	12 (0°)								
2	3 (90°)								
3	6 (180°)								
4	9 (270°)								

Table 3

Minimum Wall Thickness at Extrados

Sl.	Value (mm)	From Nearest Grid Position:	
		Clock Position	Axial Location
			mm from Grayloc end of elbow

Table 4

Additional Measurements (Only if measured WT observed ≤ $0.875 \times T_{Nom}$)

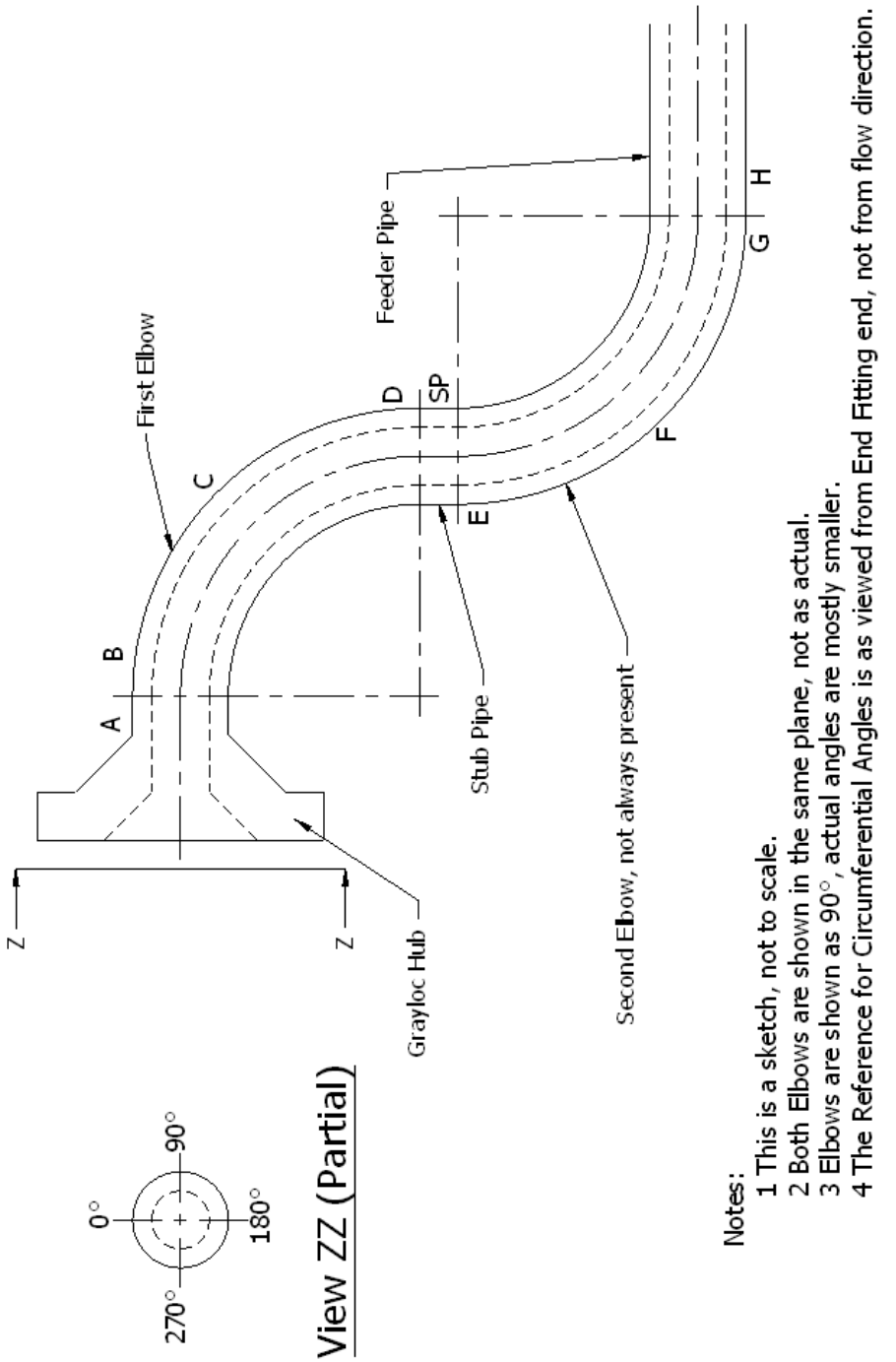
Sl.	O' clock	A	B	C	D	E	F	G	H
1	12								
2	1								
3	2								
4	3								
5	4								
6	5								
7	6								
8	7								
9	8								
10	9								
11	10								
12	11								

Table 5

Measurements on Spool Pipe (If present between Elbows 1 &2)

Sl.	O'clock	SP1	SP2	SP3
1	12 (0°)			
2	3 (90°)			
3	6 (180°)			
4	9 (270°)			

Annexure 2



PHT FEEDER THICKNESS MEASUREMENT LOCATIONS

Notes:
1 This is a sketch, not to scale.
2 Both Elbows are shown in the same plane, not as actual.
3 Elbows are shown as 90°, actual angles are mostly smaller.
4 The Reference for Circumferential Angles is as viewed from End Fitting end, not from flow direction.

Annexure-3

Measurement Locations/ Marking of grid for UTG of component to be examined for FAC in Secondary Cycle Piping

Mark the axial and circumferential grid as applicable using high temperature marker on the surface of component where measurement is to be taken. refer enclosed sketch in Fig-I to VIII

i. Axial grid lines are referred as A1, A2, A3 …….. in clock wise direction and circumferential grid lines are referred as C1, C2, C3 …… in the direction of flow. Axial grid line orientation A1 is taken as reference orientation and same is marked as follows:
ii. For the horizontal / vertical run straight pipe upstream/ downstream of CV/ Valve, the drive shaft (for reference) orientation shall be considered as A1 orientation.
iii. Horizontal run straight pipe upstream/ downstream FE RO, NRV and Nozzle the 12'O clock orientation shall be considered as A1 orientation.
iv. Vertical run straight pipe upstream/ downstream FE RO, NRV and nozzle, north direction shall be considered as A1 orientation.
v. For elbows, extrados orientation shall be considered as A1 orientation.
vi. For branch Tee, the branching orientation shall be considered as A1 reference orientation.
vii. For reducer Higher diameter size shall be taken for number of axial spots and gradually matched with lower size diameter with same number of spots in lower size for marking, Thickness measurement shall be towards flow direction e.g. 100 X 200 NB Reducer 12 axial spots for 100 NB (grid size 30 mm) and 14 axial spots for 200 NB (grid size 50 mm)in such case 14 axial spots shell be taken in straight line to mach pattern with lower diameter.
viii. In all above cases, A1, A2, A3 ……. Grid lines are marked according to the grid spacing based on pipe size in clockwise direction looking at the direction of flow are marked starting circumferential grid line C1, C2, C3 …….. are marked starting from upstream portion of pipe (area of interest) in the direction of flow. Circumferential grid lines are marked C1, C2, C3 ……. Starting from upstream portion of pipe (area of interest of the flow at an interval of grid spacing given in the table below).
ix. Intersection point of A_1- C_1 are marked ↑ / → on the pipeline using high temperature permanent marker for any cross measurement/ future reference.

Successive grids sizes are as given in the following table:

Diameter of Pipe/ Fitting	Grid Spacing
≤ 50 NB	4 Readings for Circumferential 90^0 apart and 30mm apart for Axial
> 50 NB to ≤ 100 NB	30 mm
>100 up to ≤500 NB	50 mm
>500 up to ≤1000 NB	100mm

x. To obtain more realistic results in Corrosion Rate and Residual Life calculations for Reducer/Expander, upto two grid points from their smaller ends are to be considered as components with their smaller end sizes and rest portion is to be considered with larger end sizes. Similarly all Tees (especially unequal tee) are to be considered as two separate components with their corresponding sizes. Two row grid points additional readings in pipe connecting to Tee shall be measured.

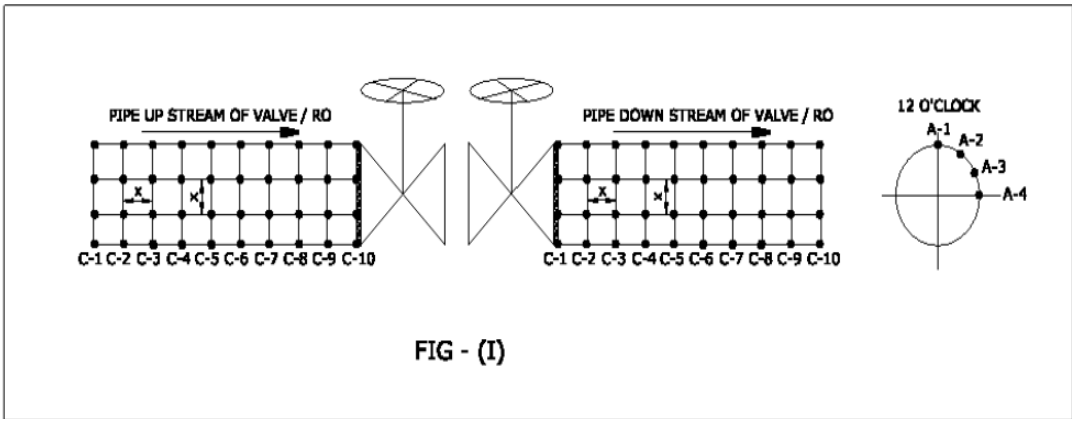


FIG - (I)

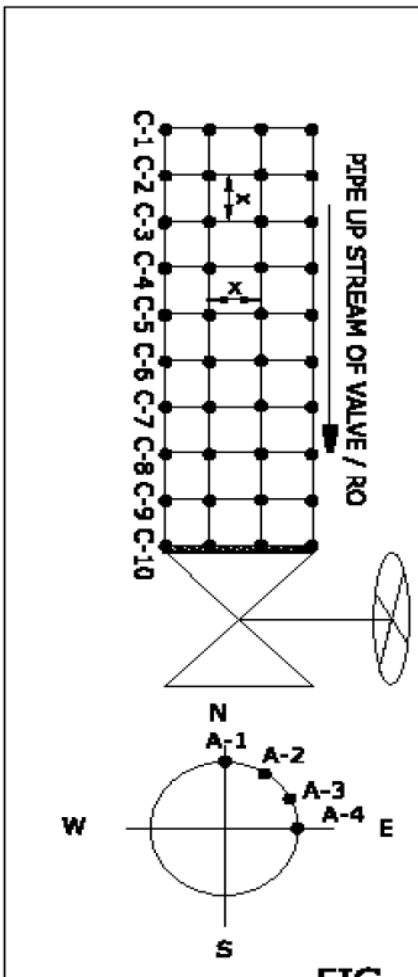


FIG - (II)

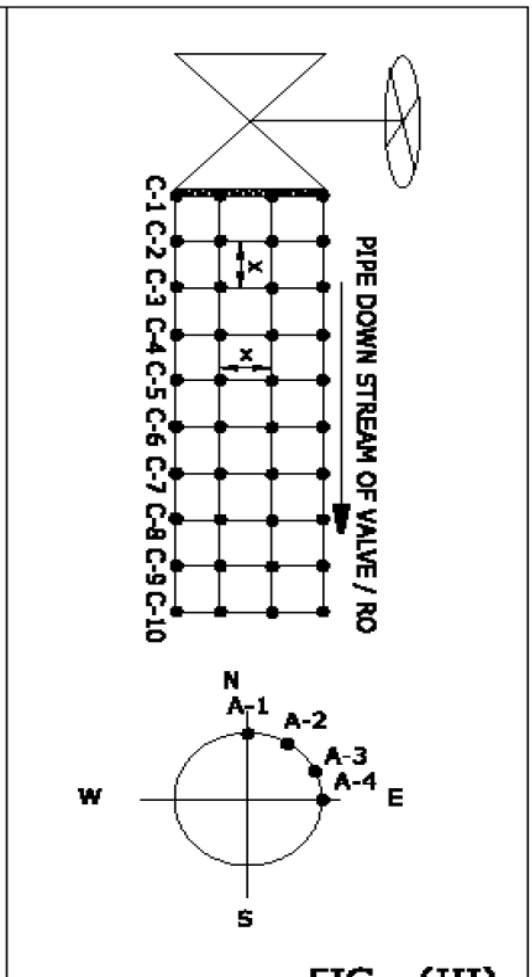


FIG - (III)

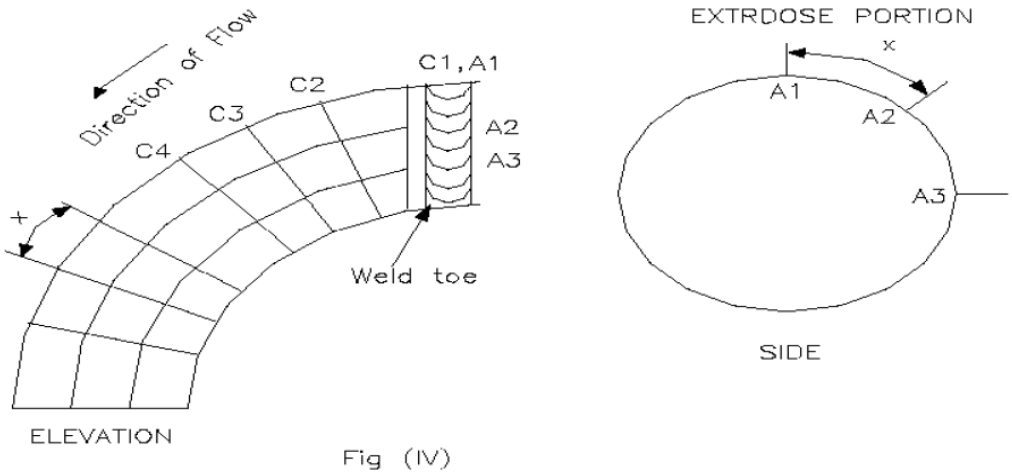
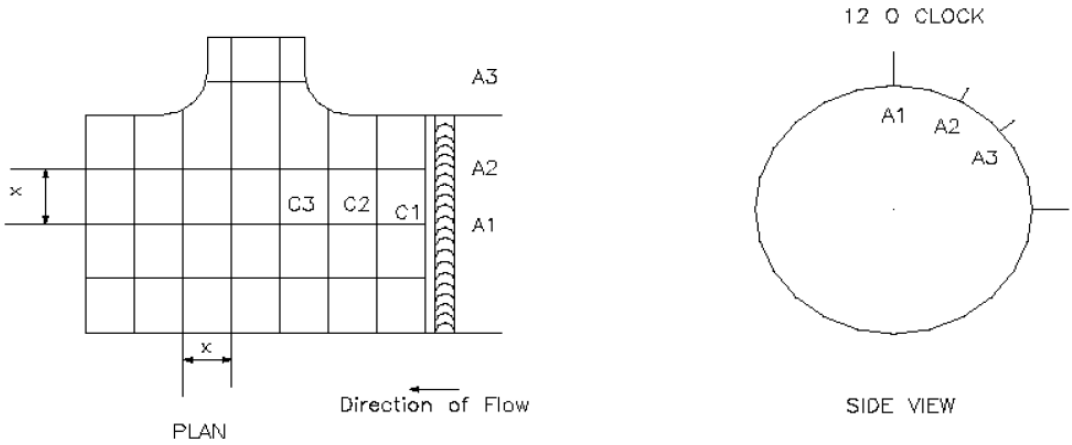


Fig (IV)

ELBOW



Value of x specified in Table 1

MAIN HORIZONTAL BRANCH HORIZONTAL

Fig (V)

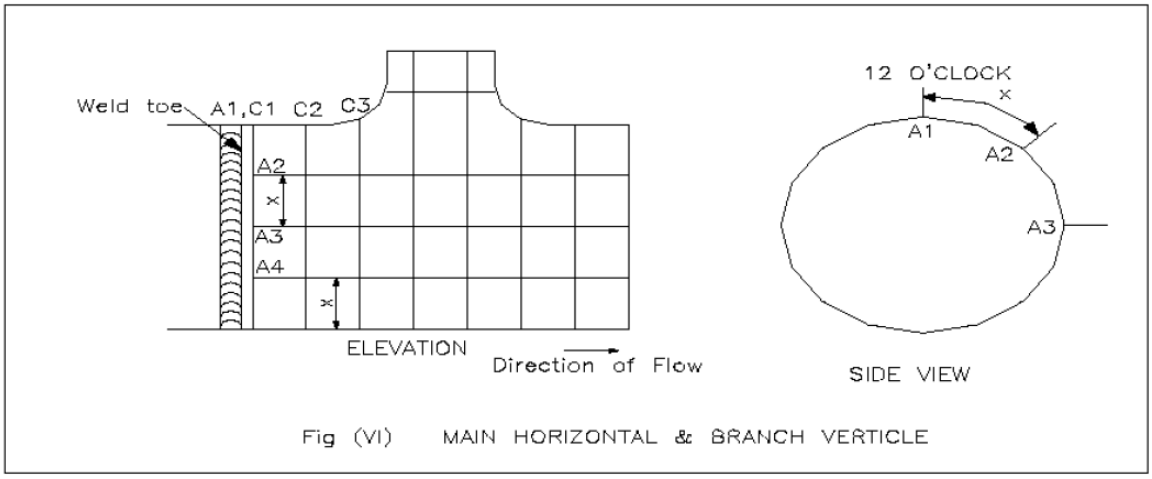


Fig (VI) MAIN HORIZONTAL & BRANCH VERTICLE

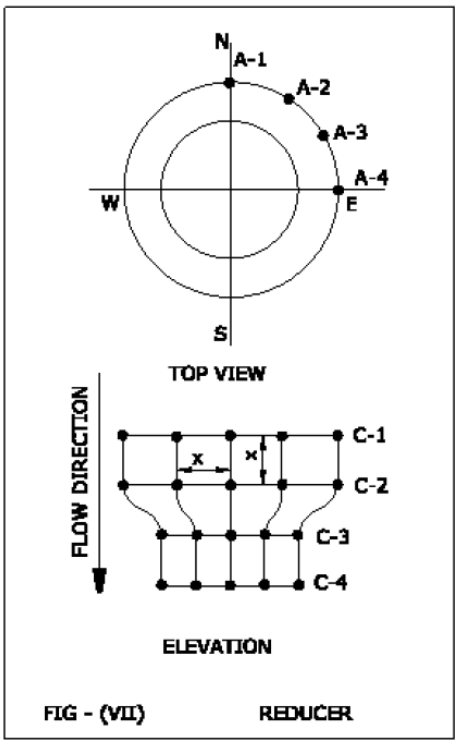


FIG - (VII) REDUCER

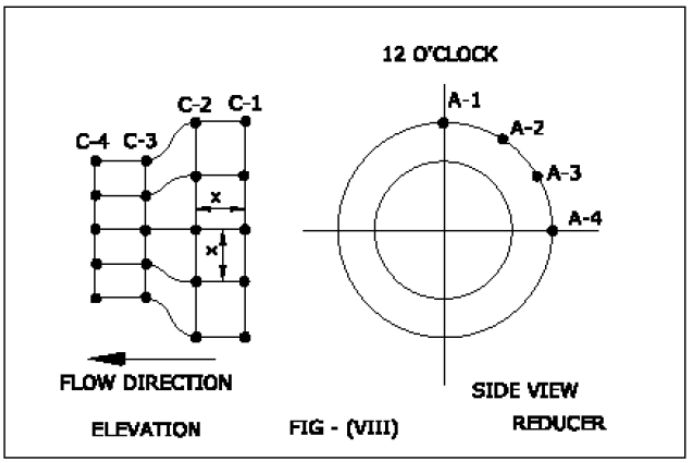


FIG - (VIII) REDUCER

SAMPLE UTG FORMAT/ ULTRASONIC THICKNESS MEASUREMENT DATA SHEET

Component No

NUCLEAR POWER CORPORATION OF INDIA LIMITED

ULTRASONIC THICKNESS MEASUREMENT REPORT

Report No								Unit								Date of Inspection									
Ref Drawing No								Component type								SIZE									
Line No.and Description								Material								Schedule									
System								Location								Sch Thickness									
Calibration check before measurement								**Calibration check after measurement**								Grid size									
AXIAL / GRID	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**	**C16**	**C17**	**C18**	**C19**	**C20**	**C21**	**C22**	**C23**	**C24**	**C25**
A1																									
A2																									
A3																									
A4																									
A5																									
A6																									
A7																									
A8																									
A9																									
A10																									
A11																									
A12																									
A13																									
A14																									
A15																									
A16																									
A17																									
A18																									
A19																									
A20																									
A21																									
A22																									
Minimum Thickness Noticed																									
Examination Done By																									
Report Reviewed By					**Name**							**NPCIL**													

Page 1 of 1

SAMPLE UT THICKNESS GAUGING TECHNIQUE SHEET

VENDOR:

SUB VENDOR:

NDT Method and Tech Sheet No.		
1	PO No.	
2	QA Ref.No./Unit/Area	
3	Basis of inspection	ISI/PSI/MFG.
4	Scope and applicability	Random/100%/
5	Personnel qualification	ISNT/ASNT
6	Material	CS/SS
7	Item	Elbow/pipe/tee/reducer
8	Item condition	Painted/Rusted/Pitted
9	Dimension/diameter	
10	Thickness	Schedule/....mm
11	Surface condition	Forged/machined
	Surface Requirement	Smoothness of contact surface shall be between 3.2 µm to 6.3 µm
12	Type of thickness gauge	make /model sr.no.
13	Resolution	0.01/0.1
14	Repeatability	
15	Probes	Make, Model, Type, Size, Frequency, Serial Number
16	Probe dia	
17	Recommended probe dia for the given job	Based on curvature effect
18	Probe cable	Make, Model, Type, Length, Instrument Connectors, Probe Connectors
19	Calibration block	Step Wedge/V2 block
20	Reference Block(with same curvature)	Same material block(with low/high thickness)
21	Couplant	Grease/Oil/Water
22	Reference Documents(QAD Proc.NPCIL spec/HQI)	
23	Acceptance standard	Attach
24	Report format	Standard/Attach
25	Any other information	

Note: The above tech sheet is for Reference/Guidance. User to make detailed Tech sheet.

Reviewed By (Sub Vendor)	Accepted By (Main Vendor)	NPCIL (Procurement/Indentor)	NPCIL(QA): For NDT Std.Tech.Requirements:

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

DOCUMENT NO: QAD/NDT-PROC/ET-01 REV- 03

TITLE	**PROCEDURE FOR EDDY CURRENT EXAMINATION OF HEAT EXCHANGER TUBES**

This procedure can be used as reference procedure. A "Technique Sheet/Job specific procedure" is to be prepared identifying the NDT process variables and identifying "Acceptance criteria" (NPCIL Specification / Code clause) for a given application by the User/Vendor (as applicable).

REVISION NO.	**0**	**1**	**2**	**3**
DATE OF ISSUE (Month/Year)	**Jan-2002**	**March-2007**	**Jan-2013**	**August-2017**
TOTAL NO. OF PAGES (Including cover sheet)	**10**	**16**	**15**	**17**

REVISION CONTROL SHEET

PROCEDURE FOR EDDY CURRENT EXAMINATION OF HEAT EXCHANGER TUBES
DOCUMENT NO: QAD/NDT-PROC/RT-01 R3

Rev. No. & Date	Description of Revisions		
PP-P-1962 R 0 (Jan-2002)	Description of Revision: Original		
	Prepared by B.B.Murthy	Reviewed by M.Ahmed	Approved by R.S.Vaghasiya
PP-P-1962 R 1 (Mar-2007)	Description of Revision: Mandatory revision		
	Revised by M.B.Jadhav	Reviewed by R.S.Vaghasiya	Approved by R.S.Vaghasiya
PP-P-1962 R 2 (Jan-2013)	Description of Revision: Editorial changes and changes as per latest codes/ standards		
	Revised by M.M.Parikh	Reviewed by M.B.Jadhav	Approved by K.P.Dwivedi
QAD/NDT-PROC/ ET-01 R3 (August 2017)	Description of Revision: Changes as per latest Codes/ Standards/Guides in clauses:2,5,6,7 , 9 , 10,13 and Annexure IV		
	Prepared by (Abhinav Pandey) EE(QA)	Reviewed by (M.B.Jadhav) ACE(QA) A.K.Deshmukh CE(QA) A.K.Singh AD(QA)	Approved by L K Jain ED(QA)

1.0 Purpose:

This procedure describes the equipment and methods as well as the personnel qualifications essential for the performance of the eddy current examination of all Heat Exchanger tubes, except Steam Generators (as a requirement of Pre-Service Inspection (PSI) / In-service Inspection (ISI)) to collect baseline data & probable flaws, if any for comparison to the future ISI data during PSI & to detect the degradation of the tubes due to service induced conditions like localized corrosion / erosion, fretting damage during ISI and is in accordance with the requirements of Section XI Appendix IV, and Section V Article 8 Mandatory Appendix II of ASME BPVC 2015.

2.0 Scope:

This procedure is applicable to thin walled tubes covered in Annexure-I and capable to detect localized corrosion/erosion, fretting damage by using dual frequency self-comparison differential mode technique and bobbin probe. This procedure is also capable to detect deterioration of the tubes at the Tube-Support Plate locations by eliminating the signals corresponding to Tube-Support Plates by using an electronic mixer.

3.0 Reference Documents:

The following documents were referred for this procedure:

a) ASME-Boiler & Pressure Vessel Code, Section-XI of 2015.
b) ASME-Boiler & Pressure Vessel Code, Section-V of 2015.
c) CSA Standard N 285.4-014, Periodic Inspection of CANDU Nuclear Power Plant Components.

4.0 Personnel Qualification:

a) Personnel performing examination in accordance with this procedure shall be certified at least to level I / II in ET by ISNT /ASNT.

b) Personnel responsible for data analysis shall be certified to level – II / III. In ET by ISNT /ASNT.

5.0 Equipment:

5.1 Eddy Current Tester:

Eddy Current Tester shall have of the following basic capabilities:

a) EC Tester capable of at least two Frequency and two channel testing (Analog or Digital)
b) Frequency range from 500 Hz to 1 Mhz .
c) Capability of performing dual frequency data acquisition in differential mode
d) Eddy current data presentation in phase amplitude form on X-Y screen for both the channel and y-t mode strip charts for at least two channels simultaneously.

e) Phase angle rotation for signal to be adjustable from 0 to 360 degrees with angle increments of minimum 1 degree.
f) Signal amplitude magnification to be adjustable through Gain control having a range of around 74 dB in steps of 1 dB increment. (The value of 74 dB is a representative value. The gain should be sufficient to effectively satisfy the equipment calibration requirements as mentioned at clause 6.6)
g) Eddy current data to be recorded in real time raw data on non-volatile medium e.g. computer hard disk, CDs or equivalent recording medium
h) Replay of all channels of recorded data.
i) Facility to obtain hard/soft copy printout for selected combination of strip chart patterns.
j) In case of digital equipment, Data capture rates of at least 600 samples per channel per second with a digital resolution of minimum 12 bits.
k) The system shall have capability of performing on-line mixing for cancellation of Tube Support Plate (TSP) signal.
l) Analysis system to be capable of measuring phase angle in increments of minimum 1 degree and amplitude measurement upto +/-10 volts with minimum of 0.1 Volts resolution (or equivalent measuring / scaling methodology available in the specific Eddy Current Instrument)
m) Equipment calibration should be maintained as per ASME Sec V Article 8-Mandatory Appendix II -860 requirements which state that for Analog Instruments the calibration is to be verified for set Frequency within +/- 5% and signal amplification for all channels within +/5% with each other for identical settings. Digital elements need not be calibrated.
n) The above requirements are inline with the requirements of the codes and are being satisfied by the following equipment available at site and /or used by ECT Service providers: Zetec MIZ-27, MIZ-40, and MIZ-43, ECT MAD 8D, Technofour – INSIS EX, Omni Corestar, RD-Tech., Rohman – ELOTEST, Ectane.
o) All these equipment and any other ECT Equipment, meeting requirements as laid down by codes, can be used. However, this is subject to the condition that an independent ECT Data Analysis / review software shall be provided along-with the ECT Raw Data files. This software shall have basic analysis features which can be used to quantify the ECT indications , if any,so that ECT data review can be performed at a later date as and when required for comparision of past / present signals when such a trending is required .

6.0 Calibration:

6.1 Calibration standard:

The calibration standard shall be manufactured from a defect free length of tubing from the same lot of the tubes for which ISI is to be performed or at least from the identical material, diameter and wall thickness. The following artificial defects are to be created for reference.

a) Through-wall drill hole [0.052" (1.3 mm) dia. for 3/4" (19 mm) OD tubing and smaller, and 0.067" (1.7 mm) for larger tubing.
b) Flat-bottomed drill hole 5/64” (2.0 mm) dia. 80% through from the outer tube wall surface.
c) Flat-bottomed drill hole 7/64” (2.8 mm) dia. 60% through from the outer tube wall surface.
d) Flat-bottomed drill hole 3/16” (4.8 mm) dia. 40% through from the outer tube wall surface.
e) Four flat-bottomed drill holes spaced 90 degrees apart around the circumference 3/16" (4.8 mm) dia. 20% through from the outer tube wall surface.
f) Circumferential groove 10% deep by 1/16" (1.6 mm) wide by 360 degrees on the inside tube wall surface.

Axial distance between artificial defect and distance of defect from end of the tube should be sufficient so as to avoid interference between the signals.

6.2 Alternate calibration standard:

ASME Sec V (2015) Article 8 –II 860 2.2 Calibration Std requirements state the following which is a subset of the above mentioned Cal std. Hence either of them may be used.

a) ne or four through-wall holes as follows:
    i. One 0.052 in. (1.3 mm) diameter hole for tubing with diameters of 0.75 in. (19 mm) and less, or a 0.067 in. (1.70 mm) hole for tubing with larger diameters.
    ii. Four holes spaced 90 deg apart in a single plane around the tube circumference, 0.026 in. (0.65 mm) diameter for tubing with diameters of 0.75 in. (19 mm) and less and 0.033 in. (0.83 mm) diameter for tubing with larger diameters.
b) A flat-bottom hole 0.109 in. (2.7 mm) diameter, 60% through the tube wall from the outer surface.
c) Four flat-bottom holes 0.187 in. (5 mm) diameter, spaced 90 deg apart in a single plane around the tube circumference, 20% through the tube wall from the outer surface.

[The depth of the artificial discontinuities, at their centre, shall be within 20% of the specified depth or 0.003 in. (0.08 mm), whichever is less. All other dimensions shall be within 0.003 in. (0.08 mm).]

6.3 Tube Support Plate:

Ring representing the Tube Support Plate made of similar material and having thickness equal to the thickness of the tube support plate and diameter of hole equal to the hole diameter of the tube support plate. The difference of the OD and ID of ring should be equal to the ligament dimension of the tube support plate.

6.4 Probes:

The probe should be bobbin type and having the frequency of operation as per the requirement indicated in the Annexure I for dual frequency operation. For the Monel tubes the probe should have a permanent magnet capable of magnetically saturating area of tube in vicinity of the probe to such an extent that the ECT signals due to local permeability variations (noise) are nullified so that the Signal to noise ratio of at least 3 (S/N >=3) can be achieved.

6.5 Probe pusher-puller:

Probe pushing and pulling for pre-service / in-service inspection of Tubes shall preferably be accomplished using remotely operated unit - Probe Pusher puller, having constant pulling speed of 300mm per second.

In case of manual pushing and pulling the prober shall be trained for pulling the probe at constant speed of 300mm per second. The Personnel engaged in the Probe Pushing/ pulling shall adhere strictly to the Radiation protection guidelines as indicated by Health physics Unit.

(Higher pulling speeds may be used provided the Eddy Current Tester is proven to be capable of faithful data acquisition – probe excitation and data recording; at the higher speed employed)

6.6 The following steps are to be followed for establishing the ECT for Differential Mode of testing:

a) Instrument operating procedure shall be used as part of this procedure.
b) Set the operation for differential mode.
c) Insert the bobbin coil probe into a section of the calibration standard, which is free of defect and balance the equipment as per requirement.
d) Set the prime frequency of test on one channel so that the phase angle of a signal from the four 20% flat bottom holes is 50º to 120º rotated clockwise from the signal of the through-the-wall hole. Refer to Annexure-I for the representative value of prime frequency of operation for different tube materials and various tube dimensions.
e) The sensitivity should be adjusted to produce a response from the through-wall hole(s) with a minimum vertical amplitude of 50% of the full Lissajous display height.
f) Adjust the phase or rotation control so that the signal response due to probe motion, or the 10% deep circumferential inside diameter groove, or both, is positioned along the horizontal axis of the display ±5 degree. Also it shall be verified while pulling the probe, that the trace display for the four 20% flat bottom holes goes down and to the left first, followed by an upward motion to the right, followed by a downward motion returning to the point of origin. A cross check is to verify that the signal due to 100% through hole is close to 40 degrees (measured clockwise from the horizontal) and the signal progresses

down and to the right first, followed by an upward motion to the left, followed by a downward motion to the right returning to the point of origin.

g) Set auxiliary frequency on second channel to a value of Prime frequency divide by 2 thus getting optimum response from tube support plate suitable to be combined (mixed) with Prime frequency signal for suppression of tube support plate signal.

h) Set the gain for the second frequency such that the signal for TSP is not saturated. See clause "m" of this sub section.

i) Adjust the phase or rotation control for second frequency in an identical manner as mentioned above in clause "f"

j) Perform the mixing of the Prime frequency and second frequency signal to cancel the TSP signal with the TSP placed in defect free area of the tube. Verify that the mix channel shows TSP signal is cancelled to the extent that S/N ratio is better than 3

k) Adjust the phase or rotation control for Mix Channel in an identical manner as mentioned above in clause "f"

l) Plot the calibration curve for the prime frequency and mixed channel for the depth of the defect verses the phase angle. The calibration curve for the second frequency shall also generated for independent review.

m) In case the TSP signal is saturated in the Prime Frequency as well as prime frequency divide by 2, a suitable gain reduction shall be made and recorded in the report. In this case the evaluation should be done with suitable magnification on display. If the ECT signals for TSP will be saturated, improper mixing will be observed in the mixed channel which will result in difficulty in analysis of the data at TSP location.

All calibration data is to be recorded in the standard format - calibration records enclosed as Annexure III

6.7 Calibration frequency: Calibrate the equipment:

a) Prior to the commencement of the eddy current examination of the heat exchanger tubes.

b) At the end of the Eddy Current Examination.

c) After replacement of any component of the test system, i.e. Probes, Eddy Current Tester, extension cables, recording instrument or any other part of system hardware.

d) At any time that malfunction / major drift in calibration is suspected. After rectification of the malfunction, recalibration shall be done. All the tubes inspected in the period of malfunction (ie. since last known healthy calibration) shall be re-inspected.

e) Calibration verification shall be done at begining and end of each unit of data storage of the recording media ie. Magnetic cartridge, CD, HDD etc.

f) Calibration verification shall be done at an interval of four hours of continuous operation.

Instrument operating manual shall be used for setting the instrument parameters.
A Signal to noise ratio of better than 3 should be maintained throughout

7.0 Precautions:

a) All personnel to be engaged in eddy current inspection program at operating plants shall have received instructions in and understand the radiation protection rules and guidelines in effect on the plant site.
b) All personnel to be engaged in the test program shall wear protective clothing and follow instructions regarding radiation protection as recommended by station Health Physics Unit.
c) All personnel entering a radiation work area will have proven their ability to work using a facemask, airline respirators, ventilated Plastic suits and other relevant radiation protection equipment.
d) Prior to actual work ALARA meeting as and when applicable shall be conducted between executing agency and HPU based on radiological condition and radiation protection/ precaution required. ALARA is prime requirement while performing ECT of Hxs.
e) Please refer to clause no 13 for operating experience.

8.0 Examinations:

8.1 Prerequisites:

8.1.1. Documents:

The following documents are required for the performance of the eddy current inspection programs utilizing the methods described in this procedure.

a. Tube sheet maps marked to designate the extent of the examination to be performed. (Sample OR 100% tubes to be scanned shall be clearly indicated)
b. Heat exchanger drawings indicating complete details regarding tube material, diameter and wall thickness, straight length, minimum and maximum bending radius of tubes, number of the tube support plates and its location, material, thickness, and ligaments distance, the material of the tube sheet and thickness of it and also any structural members used in contact with tubes.
c. Information regarding existing plugged tubes based on previous PSI/ISI reports.

8.1.2 PSI:

The tubes must be thoroughly cleaned and ensured to be free from metallic / conductive particles both from inside and outside of tubes so that the presence of magnetic particle does not produce a noisy signal during the PSI campaign. PSI should be conducted at vendor's place or NPCIL sites whichever is applicable.

8.1.3 ISI:

8.1.3.1 Plant condition:

The plant must be shut down with heat exchanger isolated, drained and dried from tube side and preferably also from shell side. The Heat Exchanger shall be opened to access to the tube sheet face. Air movers shall be attached to circulate air through the tubes to dry them and the tube sheet. It should be ensured that the inside surface of all the tubes is free from any foreign particles.

Presence of magnetic particles will produce noisy signals thereby masking the ECT signals of the indication/ flaw/ defect if any. In case of such a situation, prior cleaning of the ID of the HX tubing shall be done with a brush (or any other appropriate mechanism) from the inside of the tubing through a method similar to bobbin coil movement inside the tubing.

8.1.3.2 **Preparation:**

a. Identified activities should not commence before the pre job briefing (Encourage questioning attitude to clear any ambiguity or doubt during briefing). Pre job briefing is given to all the persons who are going to be involved in the job.
b. Ensure that all openings are blanked prior to commencement of the eddy current inspection. Nozzle covers/ FME covers are securely in place inside the vessel.
c. Radiation field & air activity is surveyed by HPU.(applicable in case of ISI)
d. Foreign Material Exclusion instructions to be given to all the persons engaged in ET job.
e. ECT equipment/Manipulator (applicable for SG Inspection) performance check carried out on Mock-Up to ensure satisfactory functioning of system in field.
f. Uninterrupted continuous power supply should be maintained through Class II/ UPS.
g. Establish Two-way communication from field to ECT control room.
h. Preferably establish CCTV system at field & monitor at ECT control room wherever possible.
i. Establish the satisfactory ECT signal from field to ECT control room through signal cables.
j. In field location, Cordon off the area where ECT equipment is kept using appropriate means and notice / lables to be affixed to indicate the Activity in progress with person to be contacted in case of difficulty.
k. A temporary rubber Station to be established near HX, to eliminate possibility of Loose contamination spread during the job.(applicable in case of ISI)
l. ECT equipment to be placed on proper / Rigid structure to prevent and damage due to toppling / falling during job execution.
m. Ensure adequate lighting using low voltage lamps etc
n. Job hazard analysis (JHA) shall be prepare by implementating group

8.2 Tube examination:

a) Record pertinent data (Plant Name, Heat Exchanger, Date of Test, tube identification scheme, Person Collecting Data and Instrument Settings) as a message in the CD / HDD, cartridge (or equivalent recording medium) and corresponding chart paper, if any.

b) Insert probe completely through the calibration standard. Record calibration standards while withdrawing probe through calibration tube covering all the defects. Cal Tube recording is preferably named as 999 – 999 for digital recording system. Place probe in defect free area and record the TSP signal by moving TSP ring to and fro for few times. Verify that the mix channel shows TSP signal is cancelled to the extent that S/N ratio is better than 3. The system is now ready for operation.

c) The leg, the row and the tube number in a particular row should identify the tube. It is preferred to identify the leg as per existing convention (Top / Bottom , Left / Right etc as applicable) . For various Heat exchangers the tube numbering scheme for "U" tube heat exchanger the rows to be counted from center to outward and the tube/column number in a row may be left to right or top to bottom when facing the tube-sheet or as per existing convention.
In case of the straight tube heat exchanger also the counting of tubes should be as per existing convention.
The tube identification system followed should be recorded as a message in the CD/HDD, cartridge (or equivalent recording medium) and corresponding chart paper, if any. Also make the entry in a register used to note the tubes tested with a sketch clearly indicating the tube identification. The tube identification scheme used shall be clearly mentioned in Annexure II

d) The total No. of tube support plates should also be noted. The numbering of tube support plates should start from Tube-Sheet side in case of "U" tubes and in case of the straight tube the counting of support plates should be from the tube sheet from where the testing is performed.

e) Physical verification by counting for the identity of the specific tube being inspected shall be performed after inspection of every fifty tubes and appropriate entry be made in CD, cartridge (or equivalent recording medium) and also at the beginning of CD container, cartridge (or equivalent recording medium).

f) Should the performance of the tube identity verification reveal an error has occurred in the recording of probe location, all tubes examined since the previous verification of location shall be re-examined.

g) The equipment calibration shall be verified and recorded at the beginning of each CD, cartridge (or equivalent recording medium). The calibration shall be checked frequently by observing that the tube support plate signals are appearing at the proper phase angle. As a minimum, the calibration will be verified at 4-hour intervals and after any equipment change and appropriate entry be made in CD, cartridge (or equivalent recording medium).

h) Should the equipment be found to be out of calibration, the equipment will be re-calibrated as per clause 6.6 of this procedure. The re-calibration will be recorded

on both the CD/HDD, cartridge and strip chart. The data analyzer will determine if it is necessary to re-inspect any of the tubes.

i) While testing "U" tubes one straight leg is tested with straight probe and the other straight leg and the bend region is tested with flexible probe.

j) The data recording shall be made during probe withdrawal. Withdrawal speed is 14" inch per second maximum. Uniform pull of 12" per second is preferred. In case of advanced EC testers having higher sample rates, higher inspection speeds can be set appropriately.

k) Since no inspection is performed during probe insertion, the insertion speed may be as rapid as possible.

l) In case of the manual probing the person who inserts the probe shall have continuous communication with the equipment operator and both personnel must concur on the tube number being examined.

m) In order to reduce radiation exposure to inspection personnel, remotely operated motorised probe pusher / pullers may be used to facilitate the inspection.

n) All Equipment Details And Instrument Settings Are To Be Recorded In The Standard Format - EQUIPMENT DETAILS AND INSTRUMENT SETTINGS enclosed as ANNEXURE II

9.0 Evaluation:

9.1 Analysis:

a) Calibration curves shall be plotted using the calibration tube data and generating Phase angle vs defect depth curve for each of the inspection frequencies.

b) All strip chart recordings/ computer charts shall be examined completely.

c) Basic analysis shall be performed using **Prime frequency** data.

d) For indications under TSP the mix channel shall be used for analysis.

e) In case of any anomalies, the second frequency shall be used for confirmations.

f) The strip chart recordings are not considered abnormal unless the excursion in Vertical Channel is more at least 3 times the background noise.

g) Any abnormal signals observed on the strip charts shall be recorded on the data sheets. The CD/HDD, cartridge (or equivalent recording media) shall be examined for each tube that is recorded as above. In some cases, it may be necessary to examine the CD/HDD, cartridge (or equivalent recording media) completely.

h) The data analyser shall :

i. Report tubes whose data is incomplete or which is un-interpretable.

ii. Report the tube requiring a re-test at one or more alternate frequencies for tubes that have a signal whose origin is difficult to ascertain.

iii. In case of pre-service inspection report all indications observed along with the approximate axial position of the indication with respect to a known structural member like tube sheet or tube support plate. The tube support plate should be numbered from tube sheet side.

iv. In case of in-service inspection report all defects having wall thinning corresponding to 20% and above. Also report all the dents having

amplitude of the order of twice the amplitude of 20% FBH signal. The axial position of the indication with respect to a known structural member like tube sheet or a tube support plate should be reported. The tube support plate should be counted from tube sheet. Always use the same identification scheme followed during pre-service inspection.

v. Preferably the tubes having defect signals should be re-recorded to confirm the presence of the defect indication.

vi. All analysis data / information shall be recorded on the standard format - EDDY CURRENT TEST EVALUATION REPORT enclosed as Annexure-IV.

10.0 Acceptance Criteria

a) As per ASME section XI the defect corresponding to wall thinning 40% from OD is allowable.

b) All the indication corresponding to wall thinning larger than 40% are to be analysed by Level II person or higher, independently.

c) All the ECT indications corresponding to OD Wall thinning greater than or equal to 20% shall be reported.

d) Based on the past experience / ECT results, the tubes recommended for plugging shall satisfy any of the following wall thinning criteria:

i. greater than 80% and any amplitude (eg. Clearly distinguishable from background noise, ie.2 times background noise equivalent to S/N of 2)

ii. wall thinning between 60% to 80% of wall thickness and signal amplitude greater than 20% FBH reference holes

iii. The tubes having wall thinning indication between 40 & 60% of the wall thickness and signal amplitude larger than 3 times the signal of 20%FBH reference hole.

Other tubes having indications should be monitored in next ISI.

However, opinion regarding the plugging is to be concurred by design group / operations group as well as station personnel. These criteria may be reviewed in future with further gain in experience.

11.0 Post examination activities: Ensure that all installed equipment has been safely dismantle and decontaminated. Post job briefing shall be carried out by implementing group.

12.0 Records:

All the recording media (including ECT digital signatures) shall be retained, for life of the plant. Reporting of ECT data shall be carried out as per attached annexure II to IV.

13.0 Operating Experience:

Radiation hotspots and high levels of loose contaminations can be present in the PHT and Mod. System heat exchangers. Appropriate decontamination measures including proper draining and drying of the tubes, flushing with fresh HO_2 /DO_2, Adequate temporary shielding, local rubber change stations, RP work wear etc shall be adhered to minimise the collective exposure and avoid contaminations.

ANNEXURE – 1

Recommended Frequency and Probe Type (Typical) * Probe type mentioned is based on earlier Zetec convention where the number is indicating Thou and F and LC indicate Flexible and Straight type probe.

Sr No.	Tube Material	OD mm	WT mm	Freq (KHz)	Recommended Probe Type*	Heat Exchanger
1.	Admiralty Brass	19.00	1.24	35	A-620-CBS, A-600 A-600-F,A-570	L.P. Heater
2.	Admiralty Brass	25.20	1.24	35	A-850-CBS A-830-CBS	Condenser
3.	Cupro Nickel 70: 30	12.7	1.47	100	A-360-LC, A-340 A-240-F,A-310	Moderator HX
4.	Cupro Nickel 70: 30	15.90	1.24	190	A-490-LC, A-460 A-490-F, A-460	End Shield Cooler
5.	Cupro Nickel 70: 30	15.9	1.42	60	A-480- LC, -A-450 A-460-F,A-430	H.P. Heater
6.	Cupro Nickel 90: 10	25.4	1.25	70	A-850-CBS A-830-CBS	Condenser
7.	Cupro Nickel 90: 10	15.9	1.42	70	A-480- LC, -A-450 A-460-F,A-430	H.P. Heater
8.	Incolloy 800	12.6	1.1	400	A 360 LC, A 340 F	Standby Cooler, Bleed cooler, Bleed Condensor, F/M Return cooler
9.	Monel	12.7	1.25	200	A-370-MBS, A-360-F/M, A-340F/M	Standby Cooler
10.	SS 304	19.0	1.25	290	A-620,A-600F	Pre Cooler
11.	SS 316 L	12.6	1.25	300	A 360 LC,A 340 F, A 360 F	Moderator Hx
12.	SS 316 L	25.4	0.711	600	A 880	Main condenser (KAPS)
13.	SS 304	15.8	0.9	500	A 500	HP heater (KAPS)
14.	Cupro Nickel 90:10	16	1.0	90	A 520	GT oil cooler (KAPS)

Note: A fill factor of 0.75 to 0.80 should be ensured

ANNEXURE-II

EQUIPMENT DETAILS AND INSTRUMENT SETTINGS

UNIT-		SHEET -	Of
USI No		REPORT No.	
DT.OF TESTING:		DATE:	

1. HEAT EXCHANGER:

Hx Name : HX No. Leg / Half tested:

2. **DRAWING No**.

3. **TUBE DETAILS:**

Material	Diameter	Wall Thickness
Straight Length	Min. Bend Rad	Max. Bend Rad
Total No. of Tubes	No. of Tubes Already Plugged:	

4. **TUBE SHEET DETAILS:**
   Material: Thickness:

5. **TUBE SUPPORT PLATE DETAILS:**
   Material: Thickness: Number : Spacing :

6. **NUMBER OF TUBES PROBED:**

7. **PROBE USED**:

Make :	Model / Type No.
Shaft Length:	Extension Cable: Type / Length

8. **TEST EQUIPMENTS:**

(A)	EDDY CURRENT TESTER	Make: Model: Sr No :
(B)	Any Other Accessory to EC Tester	If applicable

9. **TEST MODE :** DUAL FREQUENCY DIFFERENTIAL

10 **EQUIPMENT SETTING:**

EDDY CURRENT TESTER	CHANNEL-1	CHANNEL-2	MIX
FREQUENCY			
GAIN			
PHASE			

11. **NOTATION OF TUBES:**
    ROW No. :
    TUBE No. :
12. **OBSERVATIONS:**
13. **TUBES ALREADY PLUGGED:**
14. **TUBES RECOMMENDED FOR PLUGGING:**
15. **ANY OTHER RELEVANT INFORMATION:**

DATA RECORDED BY **Signature**	**VERIFIED BY:** **Signature**
NAME:	NAME:
NDT Qualification:	NDT Qualification:

ANNEXURE III

CALIBRATION RECORDS

1) **CALIBRATION STANDARD:** Sr no:

(FABRICATED AS PER THE REQUIREMENT OF ASME-SEC-V Article 8)

2) **CALIBRATION TABLE:**

DEFECT	PRIME Freq		2nd Freq		MIX	
	PHASE ANGLE (DEG.)	AMPLITUDE (VOLTS)	PHASE ANGLE (DEG.)	AMP (V)	PHASE ANGLE (DEG)	AMP (V)
100% THROUGH						
80% FBH (OD)						
60% FBH (OD)						
40% FBH (OD)						
20% FBH (OD)						
10% ID GROOVE						
Samples Per Second: Minimum 600 per channel						

1) Calibration Curve of Phase angle vs Flaw Depth (%) to be generated .

Remarks:

DATA RECORDED BY **Signature**	**VERIFIED BY:** **Signature**
NAME:	NAME:
NDT Qualification:	NDT Qualification:

ANNEXURE-IV

EDDY CURRENT TEST EVALUATION REPORT

SITE / UNIT :
HX :
LEG :
DATE :
PAGE No. : ___ of __

Sr No	Tube Identification **TUBE No. ROW-TUBE-LEG**		Observation Type *	Percentage Thinning				Current Amp (V) Pri/Mix	Loc **	Remarks
				Prime / Ch No		Mix				
				Prev	Curr	Prev	Curr			

* Typical Observation types:

TS = Tube Sheet	TSP = Tube Support Plate	PNG = Probe Not Going
DNT = Dent	PILG = Pilgering Noise	NOISE = Electrical Noise
ID = ID indication	OD = OD indication	DIST = Distorted TSP Signal
M = Severest of Multiple Indications		

** Locations for observations:

Between Top of Tube Sheet (TTS) and Tube Support Plate 1 (TSP1) OR
Between TSP No___ and TSP No ___ **OR** Between Grid No ____and Grid No ____
OR Beyond Grid No _____ **OR** In Beyond Region

Remarks:

DATA REPORTED BY Signature	**VERIFIED BY: Signature**
NAME:	NAME:
NDT Qualification:	NDT Qualification:

TITLE	PROCEDURE FOR EDDY CURRENT TESTING OF TUBES

This procedure can be used as reference procedure. A "Technique Sheet/Job specific procedure" is to be prepared identifying the NDT process variables and identifying "Acceptance Criteria" (NPCIL Specification / Code clause) for a given application by the User/Vendor.

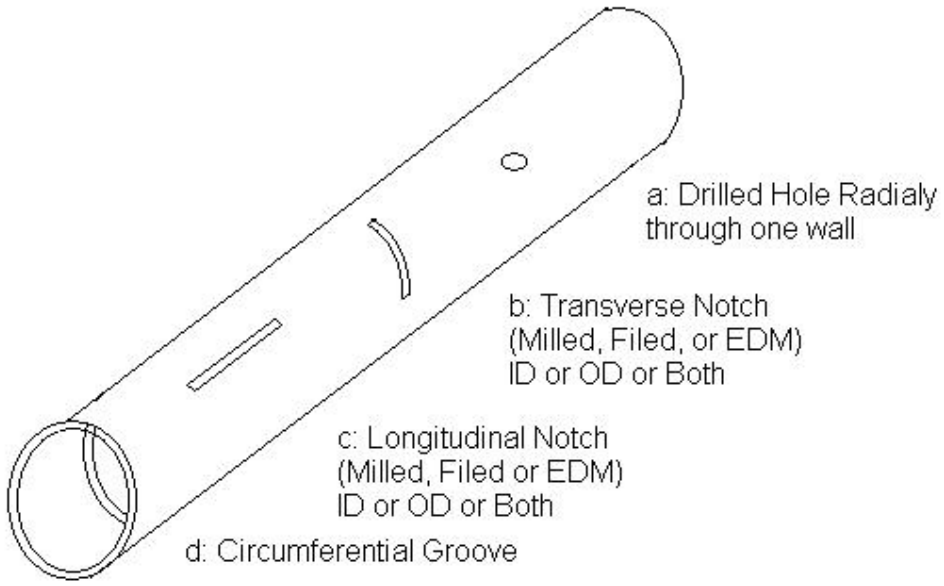
REVISION NO.	**0**	**1**	**2**
DATE OF ISSUE (Month/Year)	**May 2007**	**January 2013**	**June 2018**
TOTAL NO. OF PAGES (Including cover sheet)	**13**	**12**	**15**

Rev.No.& date	Description of Revisions		
PP-P-2347 REV. NO. 0 31-05-2007	Original		
	Prepared By	Reviewed By	Approved By
PP-P-2347 REV. NO. 1 January 2013	Editorial changes as per codes/ standards		
	Revised By	Reviewed By	Approved By
	M.M.Parikh QA, KAPS	M.B.Jadhav QA-HQ	K.P.Dwivedi ED(QA)
QAD-NDT-PROC- ET-03/Rev.2 June 2018	Editorial changes in the clause nos.9.1,11 and Annexure-I		
	Revised By	Reviewed By	Approved By
	M.B.Patel SO/E QA KAPS	M.B.Jadhav 15/6/18 ACE (QA) HQ	R.K.Gupta 15.06.18 AD(QA)
		A.K.Deshmukh 15.6.18 AD(QA-Gr-4) HQ	

As indicated by A 450/A a Longitudinal notch of 0.8mm wide and depth 12.5% of wall thickness with length compatible with testing method is milled on the outer surface parallel to the longitudinal axis of the tube. (E 309 Typical values are 10% 12.5% and 20% deep and 1/4, 1/2 and 1 inch in length)

The most commonly used artificial defects are through holes as mentioned in (a) above.

Note: The values mentioned above are typical values for Al alloy, Cu alloy or Austenitic SS as per respective ASTM Std Practice. However these ASTM Std Practice do not establish Acceptance Criteria. This is established by Using party / parties.

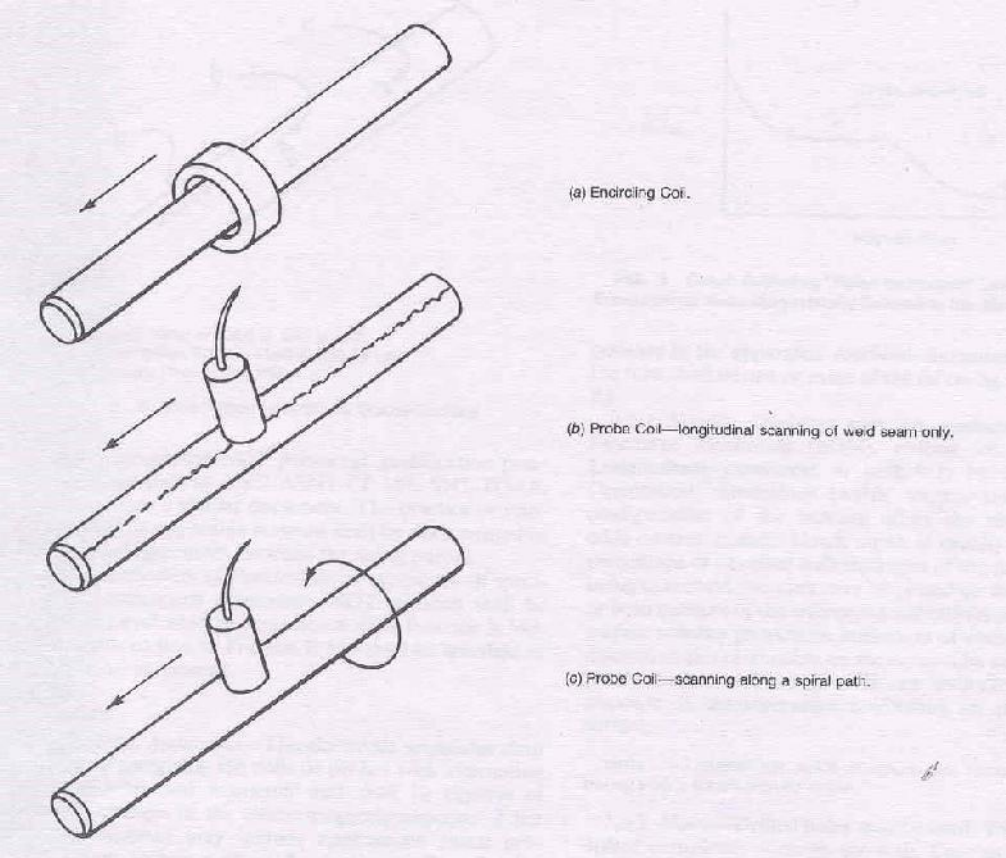


6.4 Orientation and Location of Artificial defects:

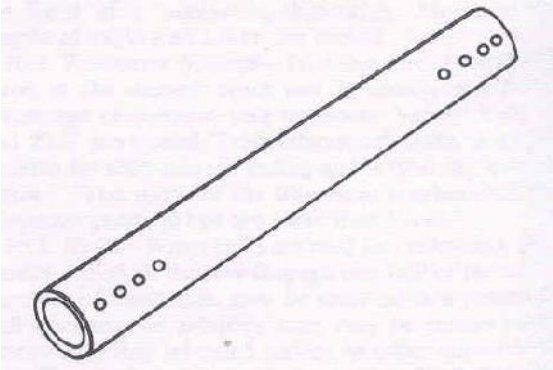
The Reference Standard should contain through holes or transverse notches at 0º, 120º and 240º axially separated sufficiently so as to provide good signal resolution and placed at least 10mm (or more) away from either end of the tube (so as to clearly generate an ECT signal which is different from the signal generated by End Effect).

Alternately two holes and two notches at 0º, 90º, 180º and 270º may be used.

The different orientations are as shown in the figures below.


(a) Encircling Coil.
(b) Probe Coil—longitudinal scanning of weld seam only.
(c) Probe Coil—scanning along a spiral path.

Wall thickness	Maximum Frequency
< 0.05 inch	100Khz
0.05 to 0.15 inch	50 Khz
>0.15 inch	10 Khz



EQUIPMENT SETTINGS

Frequency:
Sensitivity / Alarm threshold:
Phase : (wherever applicable)
Drive Speed:
S/N Ratio:
Filter settings : HP / LP (wherever applicable)
Probe Rotation RPM: (wherever applicable)
Magnetic saturation: (wherever applicable)

Make : Model / Type No.

Material Outside Diameter Wall Thickness

Defect type :	Number of defects:	Orientation:
Holes / Notches (Longitudinal or Transverse)	3 / 4	120º or 90º-180º-270º

Defect dimensions:

NUMBER OF TUBES TESTED / LENGTH TESTED
NUMBER OF TUBES ACCEPTED / LENGTH ACCEPTED
NUMBER OF TUBES REJECTED / LENGTH REJECTED

DATA RECORDED BY
Signature
NAME:
NDT Qualification(level) / Designation:

VERIFIED BY:
Signature
NAME:
NDT Qualification(level) / Designation:

NUCLEAR POWER CORPORATION OF INDIA LIMITED

(A Govt. of India Enterprise)

DIRECTORATE OF QUALITY ASSURANCE

PROCEDURE NO.: QAD/NDT-PROC/MT/01 REV. NO. 2

TITLE	PROCEDURE FOR MAGNETIC PARTICLE TESTING WITH PROD TECHNIQUE

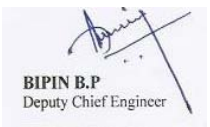
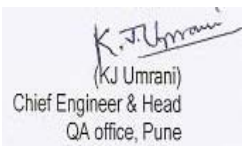
REVISION NO.	0	1	2
DATE OF ISSUE (Month/Year)	June 2007	October 2012	November 2017
TOTAL NO. OF PAGES (Including cover sheet)	6	6	21

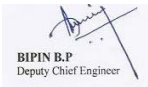
BIPIN B.P
Deputy Chief Engineer

REVISION CONTROL SHEET

SPECIFICATION No. QAD/NDT-PROC/MT/01 Rev. No. 2

PROCEDURE FOR MAGNETIC PARTICLE TESTING WITH PROD TECHNIQUE

Rev. No. & Date	Description of Revision		
PP-E-2353 R0 (June 2007)	**Description of Revision: Original**		
	Prepared by **Y. Sudhakar**	**Reviewed by** **A.K. Srivastava**	**Approved by** **C. Awasthi**
PP-E-2353 R1 (October 2012)	**Description of Revision: Editorial changes and changes as per latest codes / standards**		
	Revised by **Y. Sudhakar**	**Reviewed by** **Ranjit Singh**	**Approved by** **K.P. Dwivedi**
QAD/NDT-PROC/MT/01 Rev. No. 2 (November 2017)	**Description of Revision: Editorial changes and changes as per latest codes / standards. For details refer Summary Sheet attached**		
	Revised by  BIPIN B.P Deputy Chief Engineer **Bipin B.P.** **MT Level-II**	**Reviewed by**  (KJ Umrani) Chief Engineer & Head QA office, Pune **K.J. Umrani** **MT- Level III**	**Approved by**  **L.K. Jain** **ED(QA)**



SUMMARY SHEET OF CHANGES CARRIED OUT IN REVISION-02

1.0 COVER PAGE MODIFIED

2.0 INDEX PAGE INTRODUCED

3.0 TITLE "PURPOSE" ADDED

4.0 CLAUSE NO. 3, APPLICABLE DOCUMENTS ADDED

5.0 CLAUSE NO. 4, PROCEDURE QUALIFICATION ADDED

6.0 CLAUSE NO. 5, EQUIPMENT CONTENTS MODIFIED

7.0 CLAUSE NO. 6, CALIBRATION CONTENTS MODIFIED

8.0 CLAUSE NO 7, PRECAUTIONS AGAINST VARIOUS HAZARDS ADDED

9.0 CLAUSE NO 8, EXAMINATION CONTENTS MODIFIED & RE-EXAMINATION AFTER REPAIR ADDED

10.0 CLAUSE NO 10, ACCEPTANCE CRITERIA IS ONLY FOR REFERENCE. USER SHALL SELECT ACCORDING TO JOB/CODE REQUIREMENT.

11.0 CLAUSE NO 11, IMPORTANCE OF POST CLEANING AND DE-MAGNETIZATION HIGHLIGHTED

12.0 CLAUSE NO 12, METHODS OF RECORDING OF INDICATIONS ADDED.

13.0 TABLE NO. 1 ADDED WHICH CONTAINS ESSENTIAL & NON-ESSENTIAL VARIABLES.

14.0 ANNEXURE-1 FORMAT OF REPORT) MODIFIED FOR BETTER CLARITY.

BIPIN B.P
Deputy Chief Engineer

INDEX

1. PURPOSE

2. SCOPE

3. REFERENCE DOCUMENTS

4. PERSONNEL QUALIFICATION

5. EQUIPMENT

6. CALIBRATION

7. PRECAUTIONS

8. EXAMINATION

9. EVALUATION

10. ACCEPTANCE CRITERIA (For Reference & Guidance only)

11. POST EXAMINATION ACTIVITIES

12. RECORDS (FORMAT OF REPORT)

13. OPERATING EXPERIENCE

TABLES:

TABLE-1: REQUIREMENTS OF MAGNETIC PARTICLE EXAMINATION PROCEDURE (ESSENTIAL & NON-ESSENTIAL VARIABLES)

ANNEXURES:

FORMAT FOR REPORT

BIPIN B.P
Deputy Chief Engineer

1.0 PURPOSE:-

This procedure describes the equipment and methods as well as the personnel qualifications essential for the performance of Magnetic Particle examination on ferromagnetic materials such as iron, nickel, cobalt, and some of their alloys for detecting surface and subsurface discontinuities.

This is in accordance with the requirements of ASME Section V Article 7 & 25.

2.0 SCOPE:-

This magnetic particle examination (dry/wet, visible/fluorescent) procedure describes the requirements and acceptance criteria. The procedure is intended for locating surface and near surface discontinuities in ferromagnetic materials using PORTABLE / MOBILE UNIT WITH CABLE & PRODS (suggested/applicable for welds, crane hook, large castings, elbows/fittings, machined parts, irregular shape parts).

3.0 REFERENCE DOCUMENTS:-

3.1 ASME SECTION-V (Article-7 and Article-25) of 2015

3.2 ASME SECTION VIII, DIV-I / II (as applicable)

3.3 ASME SECTION-III , Division 1, Sub section NB/NC/ND of 2015 (as applicable)

3.4 ASTM-A-275, SE-709.

3.5 PO NO.:……. (As Applicable)

3.6 Drawing.:……. (As Applicable)

The codes and standards of latest edition / revision / addenda and specification shall be applicable.

4.0 PERSONNEL QUALIFICATION:-

Personnel qualified in accordance with Level-I/ Level-II of ISNT / ASNT shall perform the examination. Testing procedures shall be approved by level-III personnel. Personnel performing NDE and evaluation shall be qualified in accordance with written procedure conforming to the recommended practice IS 13805/ISO-9712-3/SNT-TC-1A or any other recognized practice agreed with customer. The manufacturer shall certify that each magnetic particle examiner meets the following requirements:

4.1 He/she has vision, with correction if necessary, to enable him/her to read a Jaeger Type No. 2 Standard Chart at a distance of not less than 12 in., and is capable of distinguishing and differentiating contrast between colours used. These requirements shall be checked annually.

4.2 He/she is competent in the techniques of the magnetic particle examination method for which he/she is certified, including performing the examination and interpreting and evaluating the results, except that where the examination method consists of

more than one operation, he/she may be certified as being qualified only for one or more of these operations.

4.3 Magnetic particle examination shall be performed in accordance with a written procedure, certified by the Manufacturer to be in accordance with the requirements of T-150 of ASME Section V.

4.4 Documentation showing that the required examinations have been performed and that the results are acceptable shall be made available to the Inspector.

5.0 EQUIPMENT :-

5.1 Portable/mobile unit with cable and prods.

5.2 Remote control switch (to avoid arcing), which may be built in to the prod handles in order to permit current to be applied after the prods have been properly positioned.

5.3 Direct or Rectified magnetizing current shall be used.

5.4 Prod spacing shall not exceed 8 inches (200 mm) and not less than 3 inches (75 mm). Recommended spacing shall be within 3 to 8 inches.

5.5 Pie-shaped magnetic particle field indicator, artificial flaw shims, Hall-Effect Tangential-Field Probe, Gauss meter etc.

5.6 Black Light—The black light must be capable of developing a peak wavelength output at or near 365 nm with an intensity at the examination surface not less than 1000 µW/sq. cm. Filters are used to remove the extraneous visible light and any harmful UV radiation emitted by the black light bulb. Some high intensity black light bulbs may emit unacceptable amounts of blue light that may cause indications to become invisible due to the increase in surface background. When using mercury vapour bulb a change in line voltage greater than 610 % can cause a change in black light output with consequent inconsistent performance. A constant voltage transformer may be used where there is evidence of voltage changes greater than 10 %.Black light of 1000 µW/sq. cm intensity (min.) for fluorescent, and a min. light intensity of 100 foot candle. (1000 Lux) for visible colour contrast. The intensity of ambient visible light in the darkened area where fluorescent magnetic particles examined is performed, should not exceed 2 foot candles (20 Lux).

5.7 A 100 ml capacity Pear shaped centrifuge tube with a 1.0 ml stem (0.05 ml divisions) for fluorescent particle suspensions & with a 1.5 ml stem (0.1 ml division) for non-fluorescent suspensions.

6. CALIBRATION:-

6.1 Magnetizing equipment with an ammeter shall be calibrated at least once a year or when ever equipment has been subjected to major electric repair, periodic overhaul or damage. If equipment has not been in use for a year or more, calibration shall be done prior to first use.

6.2 Visible and black light meters shall be calibrated at least once a year or when ever the meter has been repaired. If the meter has not been in use for one year or more, then calibration shall be done before being used.

6.3 Hall-effect probe gauss meters used to verify magnetizing field strength shall be calibrated at least once a year or whenever the equipment has been subjected to a

major repair, periodic overhaul or damage. If equipment has not been in use for a year or more, calibration shall be done prior to first use.

7. PRECAUTIONS:-

Those involved with hands-on magnetic particle examination exposure to hazards include:

7.1 Electric Shock and Burns: Electric short circuits can cause shock and particularly burns from the high amperages at relatively low voltages that are used. Equipment handling water suspensions should have good electrical grounds.

7.2 Flying Particles: Magnetic particles, particularly the dry ones, dirt, foundry sand, rust, and mill scale can enter the eyes and ears when they are blown off the part when applying them to a vertical or overhead surface or when cleaning an examined surface with compressed air. Dry particles are easy to inhale and the use of a dust respirator is recommended.

7.2 Falls: A fall from a scaffold or ladder if working on a large structure in the field or shop.

7.4 Fire: Ignition of a petroleum distillate bath.

7.5 Environment: Doing magnetic particle examination where flammable vapours are present as in a petrochemical plant or oil refinery. Underwater work has its own set of hazards and should be addressed independently.

7.6 Wet Floors: Slipping on a floor wetted with a particle suspension.

7.7 Shifting or Dropping of Large Components: Large components, especially those on temporary supports can shift during examination or fall while being lifted. In addition, operators should be alert to the possibility of injury to body members being caught beneath a sling/chain or between head/tail stock and the piece.

7.8 Ultraviolet Light Exposure: Ultraviolet light can adversely affect the eyes and skin. Safety goggles designed to absorb UV wavelength radiation are suggested where high intensity black light is used.

7.9 Materials and Concentrates: The safe handling of magnetic particles and concentrates are governed by the supplier's Material Safety Data Sheets (MSDS). The MSDS conforming to 29 CFR 1910.1200 or equivalent must be provided by the supplier to any user and must be prepared in accordance with FED-STD-313.

7.10 Equipment Hazards: Because of the large breadth of equipment available, unique safety hazards may exist and should be addressed on a case by case basis.

8. EXAMINATION:-

8.1 SURFACE PREPARATION:

Prior to Magnetic particle examination, the surface to be examined and all adjacent areas within at least 1 inch (25 mm) shall be dry and free of all dirt, oil, grease, lint, scale, sand, weld spatter or other extraneous matter that could interfere with the examination. Cleaning may be accomplished using detergents, organic solvents, descaling solutions, paint removers, vapour degreasing, grit blasting or ultrasonic cleaning methods. In case of nonmagnetic coatings present on the part or area being

examined, it shall be demonstrated that indications can be detected through the existing coating thickness present.

8.2 MAGNETIC FIELD STRENGTH:-

To produce interpretable indications, the magnetic field in the part must have sufficient strength and proper orientation. For the indications to be consistent this field strength must be controlled within reasonable limits, usually 625 % on single vector equipment and when using multi-directional equipment, the field strength must be controlled much closer, often within 65 %. Factors that affect the strength of the field are the size, shape, section thickness, material of the part/piece, and the technique of magnetization. Since these factors vary widely, it is difficult to establish rigid rules for magnetic field strengths for every conceivable configuration.

Sufficient magnetic field strength can be established by one of the following methods

8.2.1 Known Discontinuities: Experiments with similar/ identical parts having known discontinuities in all areas of interest.

8.2.2 Artificial Discontinuities—Verification of indications derived from AS 5371 shims taped or glued defect side in contact with the part under examination is an effective means of verifying field strength when using the continuous method.

8.2.3 Hall-effect Meter Tangential Field Strengths: A minimum tangential applied field strength of 30 G (2.4 kAM−1) should be adequate when using single vector equipment. Stronger field strengths are allowed, but it must not be so strong that it causes the masking of relevant indications by non-relevant accumulations of magnetic particles. Due to the complex number of variables, the use of Gauss meters should not be the sole source of determining an acceptable field on multi-directional techniques.

8.2.4 Circular Magnetism Hall-effect Meter Measurement: On a part with consistent diameter or thickness, the transverse probe may be placed anywhere along the length of the part as the tangential circular field is consistent across the length. The transverse probe should be positioned upright such that the circular field is normal to the major dimension of the Hall-effect sensor and within 5° of perpendicularity to the part. More than one measurement should be taken to ensure consistent readings. On parts with more than one diameter/thickness, multiple measurements should be taken to ensure a minimum measurement of 30 gauss on all areas to be examined. Measurement is made of the applied field, that is, during the magnetizing shot, not the residual flux field.

8.2.5 Longitudinal Magnetism Hall-effect Meter Measurement: On a part with consistent diameter or thickness, the probe may be placed anywhere along the length of the part, except near the poles as the tangential longitudinal field is consistent across the length, except at the poles. Measurement near the poles will yield a skewed reading due to detection of the normal flux field at each pole. Also, measurement near any geometry change that would produce a non-relevant flux leakage should be avoided. The probe should be positioned within 5° of perpendicularity to the part and such that the longitudinal field is normal to the major dimension of the Hall-effect sensor. More than one measurement should be taken to ensure consistent readings. The Hall-effect probe may be placed within the coil or outside the vicinity of the coil if the part

is longer than the width of the coil. On parts with more than one diameter/thickness, multiple measurements should be taken to ensure a minimum measurement of 30 gauss on all areas to be examined. Measurement is made of the applied field, that is, during the magnetizing shot, not the residual flux field.

8.2.6 Using Empirical Formulas: use of empirical formulas for determining field strength. Amperages derived from empirical formulas should be verified with a Hall-effect gauss meter or AS 5371 shims.

Note: The effective width of the magnetizing field when using prods is one fourth of the prod spacing on each side of a line through the prod centres.

8.3 METHOD:-

8.3.1 The ferromagnetic particles used as an examination medium can be either wet or dry, and may be either visible (non- fluorescent) or fluorescent).

8.3.2 For Dry Particles, examination shall be done by continuous method viz. magnetizing current remains on while the examination medium is being applied and while any excess of examination medium is removed.

8.3.3 For Wet Particles, the magnetising current shall be turned on after the particles are applied. Flow of particles shall stop with application of current. Wet particles applied from aerosol spray cans may be applied before and/or after magnetising current is applied. Wet particles may be applied during the application of magnetising current if they are not applied directly to the examination area and are allowed to flow over the examination area or are applied directly to the examination area with low velocities insufficient to remove accumulated particles.

8.4 TECHNIQUE:-

8.4.1 **Magnetizing Procedure**: For the Prod technique, magnetization is accomplished by portable prod type electrical contacts pressed against the surface in the area to be examined. To avoid arcing, a control switch, which may be built into the prod handles, shall be provided to permit the current to be applied after the prods have been properly positioned.

8.4.2 Magnetizing Current: Direct or Rectified magnetizing current shall be used. The current shall be as follows:

- 100 to 125 amp./inch of prod spacing for thickness ≥ 3/4” (19 mm)
- 90 to 110 amp./inch of prod spacing for thickness < 3/4” (19 mm)

8.4.3 Prod Spacing: Prod spacing shall not exceed 8 inches (200 mm) and not less than 3 inches (75 mm). Recommended spacing shall be within 3 to 8 inches. Shorter spacing may be used to accommodate geometrical limitations of the area being examined or to increase sensitivity, but prod spacing less than 3 inches are usually not practical due to banding of particles around the prods. The prod tips shall be maintained clean and dressed. To prevent heating or burning of contact area, the

prod with lead or Aluminium prod shall be used. The prod tips that contact the piece should be aluminium, copper braid, or copper pads rather than solid copper. With solid copper tips, accidental arcing during prod placement or removal can cause copper penetration into the surface which may result in metallurgical damage (softening, hardening, cracking, etc.).This precaution is more important when open circuit voltage is more than 25V.

Note:- **PROD MAGNETIZING TECHNIQUE NOT RECOMMENDED WHERE EVER SPARKING CANNOT BE TOLERATED**.

8.5 EXAMINATION MEDIUM:-

The finely divided ferromagnetic particles used for the examination shall meet the following requirements.

8.5.1 Particle Types—The particles used in either dry or wet magnetic particle testing techniques are basically finely divided ferromagnetic materials which have been treated to impart colour (fluorescent and non-fluorescent) in order to make them highly visible (contrasting) against the background of the surface being examined. The particles are designed for use either as a free flowing dry powder or for suspension at a given concentration in a suitable liquid medium.

8.5.2 Particle Characteristics—The magnetic particles must have high permeability to allow ease of magnetizing and attraction to the site of the flux leakage and low retentivity so they will not be attracted (magnetic agglomeration) to each other. Control of particle size and shape is required to obtain consistent results. The particles should be nontoxic, free from rust, grease, paint, dirt, and other deleterious materials that might interfere with their use. Both dry and wet particles are considered safe when used in accordance with the manufacturer's instructions. They generally afford a very low hazard potential with regard to flammability and toxicity.

8.5.3 Dry Particles: Dry magnetic powders are designed to be used as supplied and are applied by spraying or dusting directly onto the surface of the part being examined. They are generally used on an expendable basis because of the requirement to maintain particle size and control possible contamination. Reuse is not a normal practice. Dry powders may also be used under extreme environmental conditions. They are not affected by cold; therefore examination can be carried out at temperatures that would thicken or freeze wet baths. They are also heat resistant; some powders may be usable at temperatures up to 600°F (315°C). Some colored, organic coatings applied to dry particles to improve contrast lose their color at temperatures this high, making the contrast less effective. Fluorescent dry particles cannot be used at this high a temperature; the manufacturer should be contacted for the temperature limitations.

Advantages: The dry magnetic particle technique is generally superior to the wet technique for detection of near-surface discontinuities on parts with a gross indication size, for large objects when using portable equipment for local magnetization, superior particle mobility is obtained for relatively deep-seated flaws using half wave rectified current as the magnetizing source & ease of removal.

Disadvantages—The dry magnetic particle technique cannot be used in confined areas without proper safety breathing apparatus, can be difficult to use in overhead magnetizing positions, does not always leave evidence of complete coverage of part surface as with the wet technique, is likely to have lower production rates than the wet technique; and is difficult to adapt to any type of automatic system.

8.5.4 Wet Particle Systems: Wet magnetic particles are designed to be suspended in a vehicle such as water or light petroleum distillate at a given concentration for application to the examination surface by flowing, spraying, or pouring. They are available in both fluorescent and non-fluorescent concentrates. In some cases the particles are premixed with the suspending vehicle by the supplier, but usually the particles are supplied as a dry concentrate or paste concentrate which is mixed with the distillate or water by the user. The suspensions are normally used in wet horizontal magnetic particle equipment in which the suspension is retained in a reservoir and recirculated for continuous use. The suspension may also be used on an expendable basis dispensed from an aerosol or other suitable dispensers.

Primary Use: Because the particles used are smaller, wet method techniques are generally used to locate smaller discontinuities than the dry method is used for. The liquid vehicles used may not perform satisfactorily when their viscosity exceeds 5cSt (5 mm2/s) at the operating temperature. If the suspension vehicle is a hydrocarbon, its flash point limits the top temperature of usage. Mixing equipment for bulk reservoirs or manual agitation for portable dispensers is usually required to keep wet method particles uniformly in suspension. The wet fluorescent method usually is performed indoors or in areas where shelter and ambient light level can be controlled and where proper application equipment is available.

The colour chosen for any given examination should be one that best contrasts with the test surface. Because contrast is invariably higher with fluorescent materials, these are utilized in most wet process examinations. Fluorescent wet method particles normally glow a bright yellow-green when viewed under black light, although other colours are available. Non-fluorescent particles are usually black or reddish brown, although other colours are available. Dual-colour particles are available that are readily detectable in visible light and also display fluorescence when viewed under ultra-violet light or a combination visible and ultra-violet light.

a. Suspension Vehicles: Generally the particles are suspended in a light petroleum (low-viscosity) distillate or conditioned water.

b. Petroleum Distillates: Low-viscosity light petroleum distillates vehicles (AMS 2641 Type 1 or equal) are ideal for suspending both fluorescent and non-fluorescent magnetic particles and are commonly employed.

Advantages: Two significant advantages for the use of petroleum distillate vehicles are: (a) the magnetic particles are suspended and dispersed in petroleum distillate vehicles without the use of conditioning agents; and (b) the petroleum distillate vehicles provide a measure of corrosion protection to parts and the equipment used.

Disadvantages: Principal disadvantages are flammability, fumes, and availability. It is essential, therefore, to select and maintain readily available sources of supply of

petroleum distillate vehicles that have as high a flash point as practicable to avoid possible flammability problems and provide a work area with proper ventilation.

8.5.5 Characteristics: Petroleum distillate vehicles to be used in wet magnetic particle testing should possess the following: (*a*) viscosity should not exceed 3.0 cSt (3 mm2/s) at 100°F (38°C) and not more than 5.0 cSt (5 mm2/s) at the lowest temperature at which the vehicle will be used, in order not to impede particle mobility (*b*) minimum flash point, should be 200°F (93°C) in order to minimize fire hazards (*c*) odourless: not objectionable to user (*d*) low inherent fluorescence if used with fluorescent particles, that is, it should not interfere significantly with the fluorescent particle indications and (*e*) nonreactive; should not degrade suspended particles.

8.5.6 Water Vehicles with Conditioning Agents: Water may be used as a suspension vehicle for wet magnetic particles provided suitable conditioning agents are added which provide proper wet dispersing, in addition to corrosion protection for the parts being examined and the equipment in use. Plain water does not disperse some types of magnetic particles, does not wet all surfaces, and is corrosive to parts and equipment. On the other hand, conditioned water suspensions of magnetic particles are safer to use since they are non-flammable. The selection and concentration of the conditioning agent should be as recommended by the particle manufacturer. The following are recommended properties for water vehicles containing conditioning agents for use with wet magnetic particle testing:

a. **Wetting Characteristics**: The vehicle should have good wetting characteristics, that is, wet the surface to be examined, give even and complete coverage without evidence of de-wetting the examination surface. The surface tension (coverage) should be observed under both black light and visible light. Smooth examination surfaces require that a greater percentage of wetting agent be added than is required for rough surface. Non-ionic wetting agents are recommended

b. **Suspension Characteristics**: Impart good dispersability, that is, thoroughly disperse the magnetic particles without evidence of particle agglomeration.

c. **Foaming**: Minimize foaming; that is, it should not produce excessive foam which would interfere with indication formation or cause particles to form scum with the foam.

d. **Corrosiveness**: It should not corrode parts to be examined or the equipment in which it is used.

e. **Viscosity Limit**: The viscosity of the conditioned water should not exceed a maximum viscosity of 3 cst (3 mm2/s) at 100°F (38°C)

f. **Fluorescence**: The conditioned water should not produce excessive fluorescence if intended for use with fluorescent particles.

g. **Non-reactiveness**: The conditioned water should not cause deterioration of the suspended magnetic particles.

h. **Water pH**: The pH of the conditioned water should not be less than 7.0 or exceed 10.5.

i. **Odour**: The conditioned water should be essentially odourless.

8.5.7 Temperature Limitations: Particles shall be used within the temperature range limitations set by the manufacturer of the particles. Alternatively, particles may be

used outside the recommended temperature range provided the procedure is getting qualified at the proposed temperature.

Fluorescent / visible magnetic particle powder with kerosene/water suspension shall be run/agitated through the re-circulating system for at least 30 min to ensure thorough mixing and sampling be allowed to settle for approx. 60 min. with kerosene or 30 min with water-based suspensions. The required concentration is 0.1 to 0.4ml per 100 ml of carrier (vehicle) for fluorescent and 1.2 to 2.4 ml per 100 ml of bath sample for non-fluorescent. Concentration checks shall be made at least every eight hours. Contamination of suspensions shall be checked periodically (Details as per T-765 of ASME Sec. V, Article 7).

8.6 EXAMINATION / TEST PROCEDURE (Sequence of Operations):-

Surface to be tested shall be prepared and made suitable for Magnetic Particle examination. Surface to be tested shall be dry and free from dirt, oil, grease, scale, sand, weld spatter or other extraneous matter.

8.6.1 Contrast Enhancement: - Non-magnetic surface contrast coatings may be applied to uncoated surfaces, only in amounts sufficient to enhance particle contrast, it shall be demonstrated that indications can be detected through the enhancement coating.

The intensity of visible light in the darkened area where fluorescent magnetic particles examination is performed should not exceed 2 foot candles (fc) (20 Lux). For visible magnetic particles examination, a minimum light intensity of 100 fc. (1000 Lux) is required on the surface to be examined.

The black light intensity shall be a min. of 1000 µW/sq. cm on the surface to be examined. The black light intensity shall be verified at least once every 8 hrs, whenever the work station is changed, or whenever the bulb is changed. The examination shall be performed in a darkened area. The examiner shall be in darkened area for at least 5 min. prior to performing examination to enable their eyes to adapt to dark viewing. If the examiner wear glasses or lenses. They should not be photo sensitive. The black light shall be allowed to warm-up for a minimum of 5 minutes prior to use or measurement of the intensity of UV light emitted. Reflectors and filters should be checked daily whom in use. Cracked or broken filters shall be replaced immediately.

The prod electrodes are first pressed firmly against the part under examination. The magnetizing current is then passed through the prods and into the area of the part in contact with the prods. This establishes a circular magnetic field in the part around and between each prod electrode, sufficient to carry out a local magnetic particle examination. (**Warning:** Extreme care should be taken to maintain clean prod tips, to minimize heating at the point of contact and to prevent arc burns and local overheating on the surface being examined since these may cause adverse effects on material properties. Arc burns may cause metallurgical damage; if the tips are solid copper, copper penetration into the part may occur. Prods should not be used on machined surfaces or on precision component parts.)

a. Unrectified AC limits the prod technique to the detection of surface discontinuities. Half-wave rectified AC is most desirable since it will detect both surface and near-surface discontinuities. The prod technique generally utilizes dry magnetic particle materials due to better particle mobility. Wet magnetic particles are not generally used with the prod technique because of potential electrical and flammability hazards.

b. Proper prod examination requires a second placement with the prods rotated approximately 90° from the first placement to assure that all existing discontinuities are revealed. Depending on the surface coverage requirements,

The following procedure need to be followed.

a. Place/position the prods properly on the surface with the distance between the prods between 3 in. (75 mm) and 8 in.(200 mm) and pass the required current.

b. Press the prods against the job before application of current to avoid arcing.

c. Place the magnetic field indicator/ artificial reference standard as applicable, magnetize, and spray/pour magnetic particles on the surface while current is on, ensure field adequacy under visible / black light.

d. Magnetize the test area by placing prods and spray/pour the dry / wet magnetic particles simultaneously.

e. Give two / more shots while wet magnetic particles is on the part.

f. Examine the magnetized area between the prod spacing under black / visible light and record indications.

g. Clean the surface.

h. Change the orientation of the prods by 90 degrees to the first position.

i. Repeat the above steps from 4 to 7.

j. Shift the prods by another pitch, giving at least 10% magnetic field (locate one pole with in the 10% magnetized area of previously tested spot) overlap.

k. The prods contact position shall be rotated through 90 degrees to the first position to ensure the detection of discontinuities in different directions.

l. The entire test area shall be examined by positioning prods properly with required spacing and with at least 10% magnetic overlap.

m. Repeat step 3 as above.

n. Accumulations of excess dry particles during testing shall be removed with a light air stream from a bulb or syringe or other source of low pressure dry air. The magnetizing current shall be on while removing the excess dry particles.

8.7 REPAIR REQUIREMENTS

8.7.1 The defect shall be removed or reduced to an imperfection of acceptable size. Whenever an imperfection is removed by chipping or grinding and subsequent repair by welding is not required, the excavated area shall be blended into the surrounding

surface so as to avoid sharp notches, crevices, or corners. Where welding is required after removal of an imperfection, the area shall be cleaned and welding performed in accordance with a qualified welding procedure.

8.7.2 Any indication which is believed to be non relevant shall be regarded as an imperfection unless it is shown by re-examination by the same method or by the use of other non-destructive methods and/or by surface conditioning that no unacceptable imperfection is present.

8.7.3 After a defect is thought to have been removed and prior to making weld repairs, the area shall be examined by suitable methods to ensure it has been removed or reduced to an acceptably sized imperfection.

8.7.4 After repairs have been made, the repaired area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners and re-examined by the magnetic particle method and by all other methods of examination that were originally required for the affected area, except that, when the depth of repair is less than the radiographic sensitivity required, re-radiography may be omitted.

9. EVALUATION:-

Indications will be revealed by retention of magnetic particles. All such indications are not necessarily imperfections, however, since excessive surface roughness, magnetic permeability variations (such as at the edge of heat affected zones), etc., may produce similar indications. An indication of an imperfection may be larger than the imperfection that causes it; however, the size of the indication is the basis for acceptance evaluation. Only indications which have any dimension greater than 1/16 in. (1.5 mm) shall be considered relevant.

(a) A linear indication is one having a length greater than three times the width.

(b) A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.

(c) Any questionable or doubtful indications shall be re-examined to determine whether or not they are relevant.

Relevant indications are produced by leakage fields which are the result of discontinuities. Relevant indications require evaluation with regard to the acceptance standards agreed upon between the manufacturer/ test agency and the purchaser. Non-relevant indications can occur singly or in patterns as a result of leakage fields created by conditions that require no evaluation such as changes in section (like keyways and drilled holes), inherent material properties (like the edge of a bimetallic weld), magnetic writing, etc. False indications are not the result of magnetic forces. Examples are particles held mechanically or by gravity in shallow depressions or particles held by rust or scale on the surface.

10. ACCEPTANCE CRITERIA:- (For Reference & Guidance only)

All indications shall be evaluated in accordance with acceptance standards of referencing code. Acceptance criteria of indications shall be as per acceptance norms

specified in PO specification/Technical specification/Drawings/Datasheets etc as applicable. Following acceptance standards are given below for reference only.

10.1 As Per ASME Section VIII, Div-I of 2015 edition:

All surfaces to be examined shall be free of:

(a) Relevant linear indications

(b) Relevant rounded indications greater than 3/16 in. (5 mm)

(c) Four or more relevant rounded indications in a line separated by 1/16 in. (1.5 mm) or less, edge to edge.

10.2 As Per ASME Section-III of 2015 edition:

(a) Only imperfections producing indications with major dimensions greater than 1/16 in. (1.5 mm) shall be considered relevant imperfections.

(b) Imperfections producing the following indications are unacceptable:

(1) Any cracks or linear indications

(2) Rounded indications with dimensions greater than 3/16 in. (5 mm)

(3) Four or more rounded indications in a line separated by 1/16 in. (1.5 mm) or less edge to edge

(4) Ten or more rounded indications in any 6 in.^{2} (4000 mm^2) of surface, with the major dimension of this area not to exceed 6 in. (150 mm), with the area taken in the most unfavourable location relative to the indications being evaluated.

11. POST-EXAMINATION ACTIVITIES:-

11.1 CLEANING

Post-examination cleaning is necessary where magnetic particle material(s) could interfere with subsequent processing or with service requirements. Demagnetization should always precede particle removal. The purchaser should specify when post-examination cleaning is needed and the extent required. Typical post-examination cleaning techniques employed are: (a) the use of compressed air to blow off unwanted dry magnetic particles; (b) drying of wet particles and subsequent removal by brushing or with compressed air; (c) removal of wet particles by flushing with solvent; and (d) other suitable post-examination cleaning techniques may be used if they will not interfere with subsequent requirements.

11.2 DEMAGNETIZATION

Demagnetization shall be carried out unless otherwise specified. Demagnetize the part and check residual field. If nothing is specified residual flux shall not exceed 3 gauss for general applications and 1 gauss for critical applications as applicable.

All ferromagnetic material will retain some residual magnetism, the strength of which is dependent on the retentivity of the part. Residual magnetism does not affect the mechanical properties of the part. However, a residual field may cause chips, filing,

scale, etc. to adhere to the surface affecting subsequent machining operations, painting, or plating. Additionally, if the part will be used in locations near sensitive instruments, high residual fields could affect the operation of these instruments. Furthermore, a strong residual magnetic field in a part to be welded or electroplated could interfere with welding or plating process. Residual fields may also interfere with later magnetic particle examination. Demagnetization is required only if specified in the drawings, specification, or purchase order. When required, an acceptable level of residual magnetization and the measuring method should also be specified.

11.2.1 Demagnetization Methods: The ease of demagnetization is dependent on the coercive force of the metal. High retentivity is not necessarily related to high coercive force in that the strength of the residual field is not always an indicator of ease of demagnetizing. In general, demagnetization is accomplished by subjecting the part to a field equal to or greater than that used to magnetize the part and in nearly the same direction, then continuously reversing the field direction while gradually decreasing it to zero.

a. **Withdrawal from Alternating Current Coil**: The fastest and most simple technique is to pass the part through a high intensity alternating current coil and then slowly withdraw the part from the field of the coil. A coil of 5000 to 10,000 ampere turns is recommended. Line frequency is usually from 50 to 60 Hz alternating current. The piece should enter the coil from a 12-in. (300-mm) distance and move through it steadily and slowly until the piece is at least 36 in. (900 mm) beyond the coil. Care should be exercised to ensure that the part is entirely removed from the influence of the coil before the demagnetizing force is discontinued, otherwise the demagnetizer may have the reverse effect and actually re-magnetize the part. This should be repeated as necessary to reduce the residual field to an acceptable level. Small parts of complex figuration can be rotated and tumbled while passing through the field of the coil. Use of this technique may not be effective on large parts in which the alternating magnetic current field is insufficient to penetrate.

b. **Decreasing Alternating Current**: An alternative technique for part demagnetization is subjecting the part to the alternating magnetic field while gradually reducing its strength to a desired level.

c. **Demagnetizing with Yokes**: Alternating current yokes may be used for local demagnetization by placing the poles on the surface, moving them around the area, and slowly withdrawing the yoke while it is still energized.

d. **Reversing Direct Current**: The part to be demagnetized is subjected to consecutive steps of reversed and reduced direct current magnetization to a desired level. (This is the most effective process of demagnetizing large parts in which the alternating current field has insufficient penetration to remove the internal residual magnetization.) This technique requires special equipment for reversing the current while simultaneously reducing it in small increments.

11.2.2 Extent of Demagnetization: The effectiveness of the demagnetizing operation can be indicated by the use of appropriate magnetic field indicators. (**Warning:** A part may retain a strong residual field after having been circularly magnetized and exhibit little or no external evidence of this field. Therefore, the circular magnetization should be conducted before longitudinal magnetization if complete demagnetization is required.

If a sacrificial part is available, in the case of a part such as a bearing race that has been circularly magnetized, it is often advisable to section one side of it and measure the remaining leakage field in order to check the demagnetizing process.) After demagnetization, measurable residual fields should not exceed a value agreed upon or as specified on the engineering drawing or in the contract, purchase order, or specification.

12. RECORDS :-

Complete information shall be reported in enclosed format of M.T. report. When required by a written procedure, permanent records of the location, type, direction, length(s), and spacing(s) of indications may be made as applicable.

Non-rejectable indications shall be recorded as specified by the referencing Code Section.

Rejectable Indications shall be recorded. As a minimum, the type of indications (linear or rounded), location and extent (length or diameter or aligned) shall be recorded.

For each examination, the following information shall be recorded:

(a) procedure identification and revision,
(b) magnetic particle equipment and type of current,
(c) magnetic particles (visible or fluorescent, wet or dry),
(d) examination personnel identity and if required by referencing Code Section, qualification level
(e) map or record of indications,
(f) material and thickness,
(g) lighting equipment &
(h) Date of examination.

13. OPERATING EXPERIENCE:-

Experienced NDT personnel are most important in the interpretation & evaluation of Magnetic Particle Testing (MT) indications. Indications revealed as a result of examination provide the evaluator with size, shape and location. The inspector and other personnel involved in the evaluation must have a wide back ground in materials and fabrication technology. They should also have a broad knowledge of metals production, a basic understanding of metallurgy, knowledge of metal working and manufacturing methods and experience in the behaviour of different metals in service. In addition, inspection personnel must have good eyesight because the indication must first be seen to be detected. Inspectors must be conscious and have temperament to with stand the boredom of testing many parts without becoming careless. After many parts have been tested without detecting a discontinuity, it is a

natural human tendency to become casual. Shop floor NDT inspector must be aware of such factors and should have lot of patience and always be alert.

Case study:

Care should be taken while evaluating indications on weld joins during Magnetic Particle Examinations to verify that the indications are relevant or non-relevant . Some time nickel based electrodes are used for welding. Change in permeability gives rise to false indications. These indications can be distinguished as

a. the indications due to change in permeability are all along the surface compared to single discontinuity indication
b. These non-relevant indications can also be verified by carrying out Liquid Penetrant Examination.

TABLE-1

REQUIREMENTS OF MAGNETIC PARTICLE EXAMINATION PROCEDURE

Sl. No.	Requirement	Essential Variable	Non-Essential Variable
1	Magnetizing technique	X	-
2	Magnetizing current type or amperage outside range specified by this Article or as previously qualified	X	-
3	Surface preparation	X	-
4	Magnetic particles (fluorescent/visible, color, particle size, wet/dry)	X	-
5	Method of particle application	X	-
6	Method of excess particle removal	X	-
7	Minimum light intensity	X	-
8	Existing coatings, greater than the thickness demonstrated	X	-
9	Nonmagnetic surface contrast enhancement, when utilized	X	-
10	Performance demonstration, when required	X	-
11	Examination part surface temperature outside of the temperature range recommended by the manufacturer of the particles or as previously qualified	X	-
12	Shape or size of the examination object	-	X
13	Equipment of the same type	-	X
14	Temperature (within those specified by manufacturer or as previously qualified)	-	X
15	Demagnetizing technique	-	X
16	Post examination cleaning technique	-	X
17	Personnel qualification requirements	-	X

NOTE: "X" means **"Applicable".**

BIPIN B.P
Deputy Chief Engineer

REPORT FORMAT

MAGNETIC PARTICLE EXAMINATION

REPORT NO. : **DATE:**

PO.NO:

PROCEDURE NO. :
DRAWING NO. :
COMPONENT NAME & IDENTIFICATION:

STAGE /SURFACE CONDITION OF COMPONENT: WELD/FORGED/ROLLED/CASTING/PROOF / FINISH MACHINED

EQUIPMENT : **MAKE:** **MODEL:**

TYPE OF CURRENT , RANGE : **CURRENT: HWDC /AC** **AMP. RANGE** : **CALIBRATION DATE:**

BLACK LIGHT MAKE/ INTENSITY : **CALIBRATION DATE:**

TECHNIQUE **A) PROD** **CURRENT:**

METHOD , PRTICLE TYPE, and MAKE : **CONTINUOUS,** **DRY / WET ,**
VISIBLE/FLUORESCENT,
PARTICLE CONCENTRATION : ml per 100ml of WATER/KEROSEN **METHOD OF APPLICATION:**

REFERANCE /CALIBRATION STANDARDS : **PIE-GAUGE/KETOS-RING/ARTIFICIAL DEFECT STD**

SURFACE ENHANCEMENT COATING : **USED / NOT USED**

ACCEPTANCE STANDARD :

PRE-CLEANIG :

DETAILS OF DISCONTINUITIES :

SL.NO.	TECHNIQUE	INDICATION	SIZE	LOCATION	REMARKS

INSPECTED BY	REVIEWED BY	WITNESSED BY
(NAME & QUALIFICATION)	(NAME & QUALIFICATION)	(NAME & QUALIFICATION)

POST CLEANING : **DONE / NOT DONE**
DEMAGNETISATION: DONE /NOT DONE

NOTE:- ALL THE INFORMATION IN THE FORMAT SHOULD BE INCORPORATED AS MINIMUM BY VENDOR FOR REPORTING.

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

PROCEDURE NO.: QAD/MT/02 REV. NO. 2

TITLE	PROCEDURE FOR MAGNETIC PARTICLE TESTING WITH YOKE TECHNIQUE

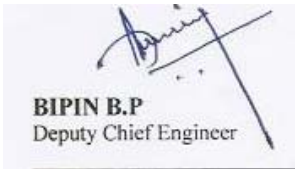
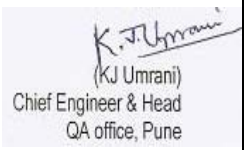
REVISION NO.	0	1	2
DATE OF ISSUE (Month/Year)	June 2007	October 2012	November 2017
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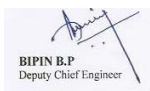
BIPIN B.P
Deputy Chief Engineer

REVISION CONTROL SHEET

SPECIFICATION No. QAD/NDT-PROC/MT/02 Rev. No. 2

PROCEDURE FOR MAGNETIC PARTICLE TESTING WITH YOKE TECHNIQUE

Rev. No. & Date	Description of Revision		
PP-E-2354 R0 (June 2007)	Description of Revision: Original		
	Prepared by Y. Sudhakar	Reviewed by A.K. Srivastava	Approved by C. Awasthi
PP-E-2354 R1(October 2012)	Description of Revision: Editorial changes and changes as per latest codes / standards		
	Revised by Y. Sudhakar	Reviewed by Ranjit Singh	Approved by K.P. Dwivedi
QAD/NDT-PROC/MT/02 Rev. No. 2 (November 2017)	Description of Revision: Editorial changes and changes as per latest codes / standards. For details refer Summary Sheet attached		
	Revised by  Bipin B.P. MT Level-II	Reviewed by  K.J. Umrani MT- Level III	Approved by  L.K. Jain ED(QA)



SUMMARY SHEET OF CHANGES CARRIED OUT IN REVISION-02

1.0 COVER PAGE MODIFIED

2.0 INDEX PAGE INTRODUCED

3.0 TITLE "PURPOSE" ADDED

4.0 CLAUSE NO. 3, APPLICABLE DOCUMENTS ADDED

5.0 CLAUSE NO. 4, PROCEDURE QUALIFICATION ADDED

6.0 CLAUSE NO. 5, EQUIPMENT CONTENTS MODIFIED

7.0 CLAUSE NO. 6, CALIBRATION CONTENTS MODIFIED

8.0 CLAUSE NO 7, PRECAUTIONS AGAINST VARIOUS HAZARDS ADDED

9.0 CLAUSE NO 8, EXAMINATION CONTENTS MODIFIED & RE-EXAMINATION AFTER REPAIR ADDED

10.0 CLAUSE NO 10, ACCEPTANCE CRITERIA IS ONLY FOR REFERENCE. USER SHALL SELECT ACCORDING TO JOB/CODE REQUIREMENT.

11.0 CLAUSE NO 11, IMPORTANCE OF POST CLEANING AND DE-MAGNETIZATION HIGHLIGHTED

12.0 CLAUSE NO 12, METHODS OF RECORDING OF INDICATIONS ADDED.

13.0 TABLE NO. 1 ADDED WHICH CONTAINS ESSENTIAL & NON-ESSENTIAL VARIABLES.

14.0 ANNEXURE-1 FORMAT OF REPORT) MODIFIED FOR BETTER CLARITY.

BIPIN B.P
Deputy Chief Engineer

INDEX

1. PURPOSE

2. SCOPE

3. REFERENCE DOCUMENTS

4. PERSONNEL QUALIFICATION

5. EQUIPMENT

6. CALIBRATION

7. PRECAUTIONS

8. EXAMINATION

9. EVALUATION

10. ACCEPTANCE CRITERIA (For Reference & Guidance only)

11. POST EXAMINATION ACTIVITIES

12. RECORDS (FORMAT OF REPORT)

13. OPERATING EXPERIENCE

TABLES:

TABLE-1: REQUIREMENTS OF MAGNETIC PARTICLE EXAMINATION PROCEDURE (ESSENTIAL & NON-ESSENTIAL VARIABLES)

ANNEXURES:

FORMAT FOR REPORT

BIPIN B.P
Deputy Chief Engineer

1.0 PURPOSE:-

1.1 This procedure describes the equipment and methods as well as the personnel qualifications essential for the performance of Magnetic Particle examination on ferromagnetic materials such as iron, nickel, cobalt, and some of their alloys for detecting surface and slightly subsurface discontinuities.

This procedure is in accordance with the requirements of ASME Section V Article 7 & 25.

2.0 SCOPE :-

2.1 This magnetic particle testing procedure is intended for locating surface and near surface discontinuities using YOKE and suggested application is for Welds, crane hooks, large castings, elbows/fittings, machined parts, and irregular shape parts in ferromagnetic materials at various stages of manufacturing. For this technique, alternating or direct current electromagnetic yokes, or permanent magnet yokes, shall be used.

3.0 REFERENCE CODES AND STANDARDS:-

a. ASME SECTION-V (Article-7 and Article-25) of 2015

b. ASME SECTION VIII, DIV-I / II (as applicable)

c. ASME SECTION-III , Division 1, Sub section NB/NC/ND of 2015 (as applicable)

d. ASTM-A-275, SE-709.

e. PO NO.:…….. (As Applicable)

f. Drawing.:……. (As Applicable)

The codes and standards of latest edition / revision / addenda and specification shall be applicable.

4.0 PERSONNEL QUALIFICATION:-

Personnel qualified in accordance with Level-I/ Level-II of ISNT / ASNT shall perform the examination. Testing procedures shall be approved by level-III personnel.

The manufacturer shall certify that each magnetic particle examiner meets the following requirements:

4.1 He/she has vision, with correction if necessary, to enable him/her to read a Jaeger Type No. 2 Standard Chart at a distance of not less than 12 in., and is capable of distinguishing and differentiating contrast between colours used. These requirements shall be checked annually.

4.2 He/she is competent in the techniques of the magnetic particle examination method for which he/she is certified, including making the examination and interpreting and evaluating the results, except that where the examination method consists of more

than one operation, he/she may be certified as being qualified only for one or more of these operations.

a. Magnetic particle examination shall be performed in accordance with a written procedure, certified by the Manufacturer to be in accordance with the requirements of T-150 of ASME Section V.

b. Documentation showing that the required examinations have been performed and that the results are acceptable shall be made available to the Inspector.

Magnetic Particle examination shall be performed in accordance with a written procedure. The written procedure shall establish a single value, or range of values, for each requirement. When procedure qualification is specified, a change of a requirement identified as an essential variable from the specified value, or range of values, shall require requalification of the written procedure and validation of the technique. A change of a requirement identified as an nonessential variable from the specified value, or range of values, does not require requalification of the written procedure. All changes of essential or nonessential variables from the value, or range of values, specified by the written procedure shall require revision of, or an addendum to, the written procedure. The procedure/technique shall be demonstrated to the satisfaction of the Inspector in accordance with the requirements of the referencing Code Section.

5.0 EQUIPMENT:-

5.1 Yoke of type permanent magnet, HWDC / AC.

5.2 Pie-shaped magnetic field indicator, Artificial reference standard with notches/holes, Magnetic field meter (Gauss meter) etc.

5.3 Black Light—The black light must be capable of developing a peak wavelength output at or near 365 nm with an intensity at the examination surface not less than 1000 µW/sq. cm. Filters are used to remove the extraneous visible light and any harmful UV radiation emitted by the black light bulb. Some high intensity black light bulbs may emit unacceptable amounts of blue light that may cause indications to become invisible due to the increase in surface background. When using a mercury vapour bulb a change in line voltage greater than 610 % can cause a change in black light output with consequent inconsistent performance. A constant voltage transformer may be used where there is evidence of voltage changes greater than 10 %. Black light of 1000 µW/sq. cm intensity (min.) for fluorescent, and a min. light intensity of 100 foot candle. (1000 Lux) for visible colour contrast. The intensity of ambient visible light in the darkened area where fluorescent magnetic particles examined is performed, should not exceed 2 foot candles (20 Lux).

5.4 A100 ml capacity Pear shaped centrifuge tube with a 1-ml stem (0.05 ml divisions) for fluorescent & with a 1.5-ml stem (0.1ml division) for non-fluorescent suspensions.

6.0 CALIBRATION:-

Magnetizing equipment with an ammeter shall be calibrated at least once a year or when ever equipment has been subjected to major electric repair, periodic overhaul or damage. If equipment has not been in use for a year or more, calibration shall be done prior to first use.

Visible and black light meters shall be calibrated at least once a year or when ever the meter has been repaired. If the meter has not been in use for one year or more, then calibration shall be done before being used.

Hall-effect probe gauss-meters used to verify magnetizing field strength shall be calibrated at least once a year or whenever the equipment has been subjected to a major repair, periodic overhaul or damage. If equipment has not been in use for a year or more, calibration shall be done prior to first use.

Prior to use, the magnetizing power of electromagnetic yokes shall have been checked within the past year. The magnetizing power of permanent magnetic yokes shall be checked daily prior to use. The magnetizing power of all yokes shall be checked whenever the yoke has been damaged or repaired.

Each alternating current electromagnetic yoke shall have a lifting power of at least 10 lb (4.5 kg) at the maximum pole spacing that will be used. Each direct current or permanent magnetic yoke shall have a lifting power of at least 40 lb (18 kg) at the maximum pole spacing that will be used. Each weight shall be weighed with a scale from a reputable manufacturer and stencilled with the applicable nominal weight prior to first use. A weight need only be verified again if damaged in a manner that could have caused potential loss of material.

7.0 PRECAUTIONS:-

Those involved with hands-on magnetic particle examination exposure to hazards include:

a. **Electric Shock and Burns**: Electric short circuits can cause shock and particularly burns from the high amperages at relatively low voltages that are used. Equipment handling water suspensions should have good electrical grounds.

b. **Flying Particles**: Magnetic particles, particularly the dry ones, dirt, foundry sand, rust, and mill scale can enter the eyes and ears when they are blown off the part when applying them to a vertical or overhead surface or when cleaning an examined surface with compressed air. Dry particles are easy to inhale and the use of a dust respirator is recommended.

c. **Falls**: A fall from a scaffold or ladder if working on a large structure in the field or shop.

d. **Fire**: Ignition of a petroleum distillate bath.

e. **Environment**: Doing magnetic particle examination where flammable vapours are present as in a petrochemical plant or oil refinery. Underwater work has its own set of hazards and should be addressed independently.

f. **Wet Floors**: Slipping on a floor wetted with a particle suspension.

g. **Shifting or Dropping of Large Components**: Large components, especially those on temporary supports can shift during examination or fall while being lifted. In addition, operators should be alert to the possibility of injury to body members being caught beneath a sling/chain or between head/tail stock and the piece.

h. **Ultraviolet Light Exposure**: Ultraviolet light can adversely affect the eyes and skin. Safety goggles designed to absorb UV wavelength radiation are suggested where high intensity black light is used.

i. **Materials and Concentrates**: The safe handling of magnetic particles and concentrates are governed by the supplier's Material Safety Data Sheets (MSDS). The MSDS conforming to 29 CFR 1910.1200 or equivalent must be provided by the supplier to any user and must be prepared in accordance with FED-STD-313.

j. **Equipment Hazards**: Because of the large breadth of equipment available, unique safety hazards may exist and should be addressed on a case by case basis.

8.0 EXAMINATION:-

8.1 SURFACE PREPARATION:-

Prior to Magnetic particle examination, the surface to be examined and all adjacent areas within at least 1 inch (25 mm) shall be dry and free of all dirt, oil, grease, lint, scale, sand, weld spatter or other extraneous matter that could interfere with the examination. Cleaning may be accomplished using detergents, organic solvents, de-scaling solutions, paint removers, vapour degreasing, grit blasting or ultrasonic cleaning methods. In case of nonmagnetic coatings present on the part or area being examined, it shall be demonstrated that indications can be detected through the existing coating thickness present.

8.2 MAGNETIC FIELD STRENGTH:-

To produce interpretable indications, the magnetic field in the part must have sufficient strength and proper orientation. For the indications to be consistent, this field strength must be controlled within reasonable limits, usually 625 % on single vector equipment and when using multi-directional equipment, the field strength must be controlled much closer, often within 65 %. Factors that affect the strength of the field are the size, shape, section thickness, material of the part/piece, and the

technique of magnetization. Since these factors vary widely, it is difficult to establish rigid rules for magnetic field strengths for every conceivable configuration.

Sufficient magnetic field strength can be established by
Known Discontinuities: Experiments with similar/ identical parts having known discontinuities in all areas of interest.

8.2.1 Artificial Discontinuities—Verification of indications derived from **AS 5371** shims taped or glued defect side in contact with the part under examination is an effective means of verifying field strength when using the continuous method.

8.2.2 Hall-effect Meter Tangential Field Strengths: A minimum tangential applied field strength of 30 G (2.4 kAM−1) should be adequate when using single vector equipment. Stronger field strengths are allowed, but it must not be so strong that it causes the masking of relevant indications by non-relevant accumulations of magnetic particles. Due to the complex number of variables, the use of Gauss meters should not be the sole source of determining an acceptable field on multi-directional techniques.

8.2.3 Circular Magnetism Hall-effect Meter Measurement: On a part with consistent diameter or thickness, the transverse probe may be placed anywhere along the length of the part as the tangential circular field is consistent across the length. The transverse probe should be positioned upright such that the circular field is normal to the major dimension of the Hall-effect sensor and within 5° of perpendicularity to the part. More than one measurement should be taken to ensure consistent readings. On parts with more than one diameter/thickness, multiple measurements should be taken to ensure a minimum measurement of 30 gauss on all areas to be examined. Measurement is made of the applied field, that is, during the magnetizing shot, not the residual flux field.

8.2.4 Longitudinal Magnetism Hall-effect Meter Measurement: On a part with consistent diameter or thickness, the probe may be placed anywhere along the length of the part, except near the poles as the tangential longitudinal field is consistent across the length, except at the poles. Measurement near the poles will yield a skewed reading due to detection of the normal flux field at each pole. Also, measurement near any geometry change that would produce a non-relevant flux leakage should be avoided. The probe should be positioned within 5° of perpendicularity to the part and such that the longitudinal field is normal to the major dimension of the Hall-effect sensor. More than one measurement should be taken to ensure consistent readings. The Hall-effect probe may be placed within the coil or outside the vicinity of the coil if the part is longer than the width of the coil. On parts with more than one diameter/thickness, multiple measurements should be taken to ensure a minimum measurement of 30 gauss on all areas to be examined. Measurement is made of the applied field, that is, during the magnetizing shot, not the residual flux field.

8.2.5 Using Empirical Formulas: use of empirical formulas for determining field strength. Amperages derived from empirical formulas should be verified with a Hall-effect gauss meter or AS 5371 shims.

8.2.6 METHOD:-

Dry/ Wet (visible/fluorescent), whichever is applicable.

The ferromagnetic particles used in an examination medium can be either wet or dry, and may be either fluorescent or non-fluorescent (Visible). Examination(s) shall be done by the continuous method.

a. Dry Particles. The magnetizing current shall remain on while the examination medium is being applied and while any excess of the examination medium is removed.

b. Wet Particles: The magnetizing current shall be turned on after the particles have been applied. Flow of particles shall stop with the application of current. Wet particles applied from aerosol spray cans may be applied before and/or after magnetizing current is applied. Wet particles may be applied during the application of magnetizing current if they are not applied directly to the examination area and are allowed to flow over the examination area or are applied directly to the examination area with low velocities insufficient to remove accumulated particles.
Note: **All examinations shall be conducted with sufficient field overlap to ensure 100% coverage at the required sensitivity**.

8.3 TECHNIQUE:-

a). Permanent magnetic/ DC electromagnetic yokes shall be capable of lifting 18 kgs (40 pounds) at the maximum pole spacing that will be used.

b). AC electromagnetic yoke shall be capable of lifting 4.5 kgs (10 pounds) at the maximum pole spacing that will be used.

8.4 EXAMINATION MEDIUM :-

The finely divided ferromagnetic particles used for the examination shall meet the following requirements.

(a) Particle Types: The particles shall be treated to impart colour (fluorescent pigments, non-fluorescent pigments, or both) in order to make them highly visible (contrasting) against the background of the surface being examined.

(b) Particles: Dry and wet particles and suspension vehicles should be in accordance with ASTM A-275, SE-709.

(c) Temperature Limitations: Particles shall be used within the temperature range limitations set by the manufacturer of the particles. Alternatively, particles may be used outside the particle manufacturer's recommendations providing the procedure is qualified in accordance with ASME Sec-V, Article 1, T-150 at the proposed temperature.

d) Dry magnetic particle powder shall provide adequate colour contrast with the surface being examined.

e) Fluorescent / visible powder with kerosene/water suspension shall be run/agitated through the re-circulating system for at least 30 min to ensure thorough mixing and sampling be allowed to settle for approx. 60 min. with kerosene or 30 min with water-based suspensions. The required concentration is 0.1 to 0.4 ml per 100ml of carrier (vehicle) for fluorescent and 1.2 to 2.4 ml per 100 ml of both sample for non-fluorescent. Concentration checks shall be made at least every eight hours.

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Contamination of suspensions shall be checked periodically (as per ASME Sec. V, Article 7).

8.5 TEST PROCEDURE:-

Satisfactory results are usually obtained when the surfaces are in the as-welded, as-rolled, as-cast, or as-forged conditions. However, surface preparation by grinding or machining may be necessary where surface irregularities could mask indications due to discontinuities.

Prior to magnetic particle examination, the surface to be examined and all adjacent areas within at least 1 in. (25 mm) shall be dry and free of all dirt, grease, lint, scale, welding flux and spatter, oil, or other extraneous matter that could interfere with the examination.

Cleaning may be accomplished using detergents, organic solvents, descaling solutions, paint removers, vapor degreasing, sand or grit blasting, or ultrasonic cleaning methods.

If nonmagnetic coatings are left on the part in the area being examined, it shall be demonstrated that indications can be detected through the existing maximum coating thickness applied. When AC yoke technique is used, the demonstration shall be in accordance with requirements of Mandatory Appendix I of ASME Sec-V, article-7.

8.6.1 Non Magnetic Surface Contrast coating:-

In case non-magnetic coatings are applied temporarily to uncoated surfaces only in amounts sufficient to enhance particle contrast, it shall be demonstrated that indications can be detected through the enhancement coating.

The intensity of visible light in the darkened area where fluorescent magnetic particles examination is performed should not exceed 2 fc. For visible magnetic particles examination, a min. light intensity of 100 fc.(1000 Lux) is required on the surface to be examined.

The black light intensity shall be a min. of 1000 micro w/sq. cm on the surface to be examined. The black light intensity shall be verified at least once every 8hrs, whenever the work station is changed, or whenever the bulb is changed.

The examination shall be performed in a darkened area. The examiner shall be in the darkened area for at least 5 minutes. Prior to performing the examination to enable their eyes to adapt to dark viewing. If the examiner wears glasses or lenses, they shall not be photosensitive. The black light shall be allowed to warm-up for a minimum of 5 minutes prior to use or measurement of the intensity of the ultraviolet light emitted. Reflector and filters should be checked daily when in use. Cracked or broken filters shall be replaced immediately.

8.6.2 Test Procedure:-

The following procedure to be followed:-

1. Place/position the yoke properly on the surface with the distance between the poles not exceeding 8 in (200 mm) and shall not be less than 3 in. (75 mm) and pass the required current.
2. Press the yoke against the job before application of current.
3. Place the magnetic field indicator/ artificial reference standard as applicable, magnetize, spray/pour magnetic particles on the surface while current is on, ensure field adequacy under visible / black light.
4. Magnetize the test area by placing yoke and spray/pour the dry / wet magnetic particles simultaneously.
5. Give two / more shots while wet magnetic particles are on the part.
6. Examine the magnetized area between the poles spacing under black / visible light and record indications.
7. Clean the surface.
8. Change the orientation of the prods by 90 degrees to the first position.
9. Repeat the above steps from 4 to 7.
10. Shift the yoke by another pitch, giving at least 10% magnetic field (locate one pole with in the 10% magnetized area of previously tested spot) overlap.
11. The yoke contact position shall be rotated through 90 degrees to the first position to ensure the detection of discontinuities in different directions.
12. The entire test area shall be examined by positioning yoke properly with required spacing and with at least 10% magnetic overlap.
13. Repeat step 3 as above.
14. Accumulations of excess dry particles during testing shall be removed with a light air stream from a bulb or syringe or other source of low pressure dry air. The magnetizing current shall be on while removing the excess dry particles.

8.6 REPAIR REQUIREMENTS

The defect shall be removed or reduced to an imperfection of acceptable size. Whenever an imperfection is removed by chipping or grinding and subsequent repair by welding is not required, the excavated area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners. Where welding is required after removal of an imperfection, the area shall be cleaned and welding performed in accordance with a qualified welding procedure.

(a) Any indication which is believed to be non-relevant shall be regarded as an imperfection unless it is shown by re-examination by the same method or by the use of other non-destructive methods and/or by surface conditioning that no unacceptable imperfection is present.

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(b) After a defect is thought to have been removed and prior to making weld repairs, the area shall be examined by suitable methods to ensure it has been removed or reduced to an acceptably sized imperfection.

(c) After repairs have been made, the repaired area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners and re-examined by the magnetic particle method and by all other methods of examination that were originally required for the affected area, except that, when the depth of repair is less than the radiographic sensitivity required, re-radiography may be omitted.

9.0 EVALUATION

Indications will be revealed by retention of magnetic particles. All such indications are not necessarily imperfections, however, since excessive surface roughness, magnetic permeability variations (such as at the edge of heat affected zones), etc., may produce similar indications. An indication of an imperfection may be larger than the imperfection that causes it; however, the size of the indication is the basis for acceptance evaluation. Only indications which have any dimension greater than 1/16 in. (1.5 mm) shall be considered relevant.

(a) A linear indication is one having a length greater than three times the width.
(b) A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.
(c) Any questionable or doubtful indications shall be re-examined to determine whether or not they are relevant.

Relevant indications are produced by leakage fields which are the result of discontinuities. Relevant indications require evaluation with regard to the acceptance standards agreed upon between the manufacturer/ test agency and the purchaser. Non-relevant indications can occur singly or in patterns as a result of leakage fields created by conditions that require no evaluation such as changes in section (like keyways and drilled holes), inherent material properties (like the edge of a bimetallic weld), magnetic writing, etc. False indications are not the result of magnetic forces. Examples are particles held mechanically or by gravity in shallow depressions or particles held by rust or scale on the surface.

10.0 ACCEPTANCE CRITERIA:- (For Reference & Guidance only)

All indications shall be evaluated in accordance with acceptance standards of referencing code. Acceptance criteria of indications shall be as per acceptance norms specified in PO specification/Technical specification/Drawings/Datasheets etc as applicable. Following acceptance standards are given below for reference only.

10.1 As Per ASME Section VIII, Div-I of 2015:

All surfaces to be examined shall be free of:

(a) Relevant linear indications

(b) Relevant rounded indications greater than 3/16 in. (5 mm)

(c) Four or more relevant rounded indications in a line separated by 1/16 in. (1.5 mm) or less, edge to edge.

10.2 As Per ASME Section-III of 2015:

(a) Only imperfections producing indications with major dimensions greater than 1/16 in. (1.5 mm) shall be considered relevant imperfections.

(b) Imperfections producing the following indications are unacceptable:

(1) any cracks or linear indications

(2) rounded indications with dimensions greater than 3/16 in. (5 mm)

(3) four or more rounded indications in a line separated by 1/16 in. (1.5 mm) or less edge to edge

(4) ten or more rounded indications in any 6 $in.^2$ (4000 mm^2) of surface, with the major dimension of this area not to exceed 6 in. (150 mm), with the area taken in the most unfavourable location relative to the indications being evaluated.

11.0 POST-EXAMINATION ACTIVITIES:-

11.1 CLEANING

Post-examination cleaning is necessary where magnetic particle material(s) could interfere with subsequent processing or with service requirements. Demagnetization should always precede particle removal. The purchaser should specify when post-examination cleaning is needed and the extent required. Typical post-examination cleaning techniques employed are: (a) the use of compressed air to blow off unwanted dry magnetic particles; (b) drying of wet particles and subsequent removal by brushing or with compressed air; (c) removal of wet particles by flushing with solvent; and (d) other suitable post-examination cleaning techniques may be used if they will not interfere with subsequent requirements.

11.2 DEMAGNETIZATION

Demagnetization shall be carried out unless otherwise specified. Demagnetize the part and check residual field. If nothing is specified residual flux shall not exceed 3 gauss for general applications and 1 gauss for critical applications as applicable.

All ferromagnetic material will retain some residual magnetism, the strength of which is dependent on the retentivity of the part. Residual magnetism does not affect the mechanical properties of the part. However, a residual field may cause chips, filing,

scale, etc. to adhere to the surface affecting subsequent machining operations, painting, or plating. Additionally, if the part will be used in locations near sensitive instruments, high residual fields could affect the operation of these instruments. Furthermore, a strong residual magnetic field in a part to be welded or electroplated could interfere with welding or plating process. Residual fields may also interfere with later magnetic particle examination. Demagnetization is required only if specified in the drawings, specification, or purchase order. When required, an acceptable level of residual magnetization and the measuring method should also be specified.

11.2.1 Demagnetization Methods: The ease of demagnetization is dependent on the coercive force of the metal. High retentivity is not necessarily related to high coercive force in that the strength of the residual field is not always an indicator of ease of demagnetizing. In general, demagnetization is accomplished by subjecting the part to a field equal to or greater than that used to magnetize the part and in nearly the same direction, then continuously reversing the field direction while gradually decreasing it to zero.

a. Withdrawal from Alternating Current Coil: The fastest and most simple technique is to pass the part through a high intensity alternating current coil and then slowly withdraw the part from the field of the coil. A coil of 5000 to 10,000 ampere turns is recommended. Line frequency is usually from 50 to 60 Hz alternating current. The piece should enter the coil from a 12-in. (300-mm) distance and move through it steadily and slowly until the piece is at least 36 in. (900 mm) beyond the coil. Care should be exercised to ensure that the part is entirely removed from the influence of the coil before the demagnetizing force is discontinued, otherwise the demagnetizer may have the reverse effect and actually re-magnetize the part. This should be repeated as necessary to reduce the residual field to an acceptable level. Small parts of complex figuration can be rotated and tumbled while passing through the field of the coil. Use of this technique may not be effective on large parts in which the alternating magnetic current field is insufficient to penetrate.

b. Decreasing Alternating Current: An alternative technique for part demagnetization is subjecting the part to the alternating magnetic field while gradually reducing its strength to a desired level.

c. Demagnetizing with Yokes: Alternating current yokes may be used for local demagnetization by placing the poles on the surface, moving them around the area, and slowly withdrawing the yoke while it is still energized.

d. Reversing Direct Current: The part to be demagnetized is subjected to consecutive steps of reversed and reduced direct current magnetization to a desired level. (This is the most effective process of demagnetizing large parts in which the alternating current field has insufficient penetration to remove the internal residual magnetization.) This technique requires special equipment for reversing the current while simultaneously reducing it in small increments.

11.2.2 Extent of Demagnetization: The effectiveness of the demagnetizing operation can be indicated by the use of appropriate magnetic field indicators. (**Warning:** A part may retain a strong residual field after having been circularly magnetized and exhibit little or no external evidence of this field. Therefore, the circular magnetization should be

conducted before longitudinal magnetization if complete demagnetization is required. If a sacrificial part is available, in the case of a part such as a bearing race that has been circularly magnetized, it is often advisable to section one side of it and measure the remaining leakage field in order to check the demagnetizing process.) After demagnetization, measurable residual fields should not exceed a value agreed upon or as specified on the engineering drawing or in the contract, purchase order, or specification.

12.0 RECORDS

Complete information shall be reported in enclosed format of M.T. report. When required by a written procedure, permanent records of the location, type, direction, length(s), and spacing(s) of indications may be made as applicable.

Non-rejectable indications shall be recorded as specified by the referencing Code Section.

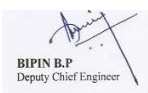
Rejectable Indications shall be recorded. As a minimum, the type of indications (linear or rounded), location and extent (length or diameter or aligned) shall be recorded.

For each examination, the following information shall be recorded:

(a) procedure identification and revision,
(b) magnetic particle equipment and type of current,
(c) magnetic particles (visible or fluorescent, wet or dry),
(d) examination personnel identity and if required by referencing Code Section, qualification level
(e) map or record of indications,
(f) material and thickness,
(g) lighting equipment &
(h) date of examination.

13.0 OPERATING EXPERIENCE:-

Experienced NDT personnel are most important in the interpretation & evaluation of Magnetic Particle Testing (MT) indications. Indications revealed by MT provide the evaluator with size, shape and location. The inspector and other personnel involved in the evaluation must have a wide back ground in materials and fabrication technology. They should also have a broad knowledge of metals production, a basic understanding of metallurgy, knowledge of metal working and manufacturing methods and experience in the behaviour of different metals in service. In addition, inspection personnel must have good eyesight because the indication must first be seen to be detected. Inspectors must be conscious and have temperament to with stand the boredom of testing many parts without becoming careless. After many parts have been tested without detecting a discontinuity, it is a natural human tendency to become casual. Shop floor NDT inspector must be aware of such factors and should have lot of patience and to be alert.



Case study:

1. Care should be taken while evaluating indications on weld joins during Magnetic Particle Examinations to verify that the indications are relevant or non-relevant . Some time nickel based electrodes are used for welding. Change in permeability gives rise to false indications. These indications can be distinguished as

a. the indications due to change in permeability are all along the surface compared to single discontinuity indication

b. These non-relevant indications can also be verified by carrying out Liquid Penetrant Examination

2. While examining various components by Yoke technique sometimes the yoke legs are adjusted to take care for job geometry. In doing so entire surface of yoke leg may not come in contact with the job under test. The yoke leg makes only partial contact. In such cases lifting power of the yoke shall be demonstrated with the limited / partial contact surface as applied on the job.

   This can happen because of wear and tear of the surface of yoke legs.

TABLE-1

REQUIREMENTS OF MAGNETIC PARTICLE EXAMINATION PROCEDURE

Sl. No.	Requirement	Essential Variable	Non-Essential Variable
1	Magnetizing technique	X	-
2	Magnetizing current type or amperage outside range specified by this Article or as previously qualified	X	-
3	Surface preparation	X	-
4	Magnetic particles (fluorescent/visible, color, particle size, wet/dry)	X	-
5	Method of particle application	X	-
6	Method of excess particle removal	X	-
7	Minimum light intensity	X	-
8	Existing coatings, greater than the thickness demonstrated	X	-
9	Nonmagnetic surface contrast enhancement, when utilized	X	-
10	Performance demonstration, when required	X	-
11	Examination part surface temperature outside of the temperature range recommended by the manufacturer of the particles or as previously qualified	X	-
12	Shape or size of the examination object	-	X
13	Equipment of the same type	-	X
14	Temperature (within those specified by manufacturer or as previously qualified)	-	X
15	Demagnetizing technique	-	X
16	Post examination cleaning technique	-	X
17	Personnel qualification requirements	-	X

NOTE: " X " means **"Applicable".**

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REPORT FORMAT

MAGNETIC PARTICLE EXAMINATION

REPORT NO. : DATE:

PO.NO. :

PROCEDURE NO. :
DRAWING NO. :
COMPONENT NAME & IDENTIFICATION :

STAGE /SURFACE CONDITION OF ITEM : WELD / FORGED/ROLLED/CASTING/PROOF / FINISH MACHINED

EQUIPMENT : MAKE: MODEL:
TYPE OF CURRENT ,RANGE : CURRENT: HWDC /AC AMP. RANGE : CALIBRATION DATE:
BLACK LIGHT MAKE/ INTENSITY : CALIBRATION DATE:
TECHNIQUE |: A) YOKE: PERMANENT MAGNET

: CURRENT: AC/HWDC

METHOD , PRTICLE TYPE,MAKE : CONTINUOUS WET , VISIBLE/FLUORESCENT,
PARTICLE CONCENTRATION : ml per 100ml of WATER/KEROSEN METHOD OF APPLICATION :
REFERANCE /CALIBRATION STANDARDS :PIE-GAUGE/KETOS-RING/ARTIFICIAL DEFECT STRD.
SURFACE ENHANCEMENT COATING : USED / NOT USED
ACCEPTANCE STANDARD :

PRE-CLEANIG :

DETAILS OF DISCONTINUITIES :

SL.NO.	TECHNIQUE	INDICATION	SIZE	LOCATION	REMARKS

POST CLEANING: DONE / NOT DONE
DEMAGNETISATION: DONE / NOT DONE

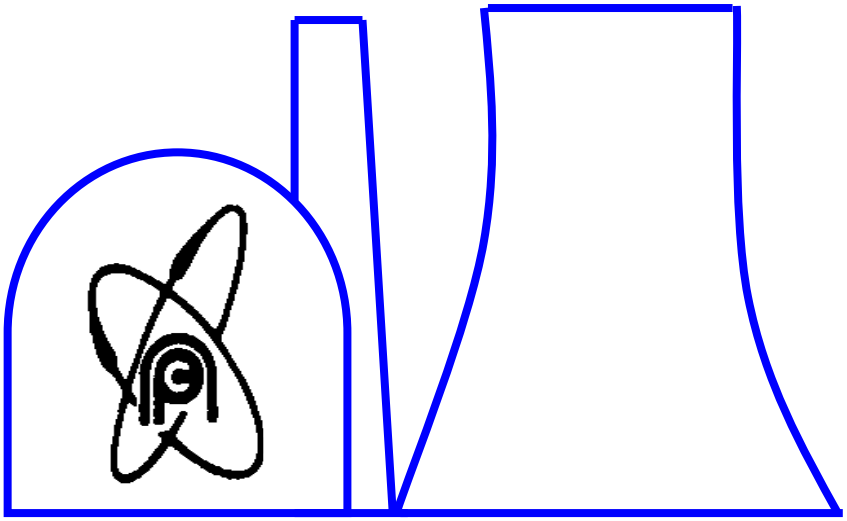
NOTE:- ALL THE INFORMATION IN THE FORMAT SHOULD BE INCORPORATED AS MINIMUM BY VENDOR FOR REPORTING.

INSPECTED BY REVIEWED BY WITNESSED BY

(NAME & QUALIFICATION) (NAME & QUALIFICATION) (NAME & QUALIFICATIO

Directorate of Quality Assurance

NDE PROCEDURE



Procedure For Magnetic Particle Testing with Wet Horizontal / Stationary Magnetic Particle Testing Machine For Gears, Disc and Flange

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

DOCUMENT NO.: QAD/NDT-PROC/MT-03 REV- 2

TITLE :	PROCEDURE FOR MAGNETIC PARTICLE TESTING WITH WET HORIZONTAL / STATIONARY MAGNETIC PARTICLE TESTING MACHINE FOR GEARS, DISC AND FLANGES

This Procedure can be used as reference procedure. A "Technique sheet/Job specific procedure" is to be prepared identifying the NDT process variables and identifying "Acceptance criteria" (NPCIL Specification /Code clause) for a given application by the User/Vendor.

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DATE OF ISSUE (Month/Year)	June 2007	October 2012	June 2017	
TOTAL NO. OF PAGES (Including cover sheet)	8	7	8	

REVISION CONTROL SHEET

Procedure For Magnetic Particle Testing with Wet Horizontal / Stationary Magnetic Particle Testing Machine For Gears, Disc and Flange

DOCUMENT No. QAD/NDT-PROC/MT-03 R2

Document No. & Date	Description of Revisions		
PP-P-2352 R0 (June. 2007)	Description of Revision: Original		
	Prepared by Y. Sudhakar	Reviewed by A.K. Srivastava	Approved by C. Awasthi
PP-P-2352 R1 (Oct. 2012)	Description of Revision: Editorial changes and changes as per latest codes/ Standards		
	Revised by Y. Sudhakar	Reviewed by Ranjit Singh	Approved by K.P. Dwivedi
QAD/NDT-PROC/ MT-03 R2 (June 2017)	Description of Revision: Editorial changes and changes as per latest codes/ Standards		
	Revised by D. S. Pandey MT-Level – III 30/06/17	Reviewed by A.L.V.S.N. Murty MT-Level – III 30/06/17	Approved by L. K. Jain ED(QA) 17/7/17

1.0 SCOPE

This magnetic particle testing(visible / fluorescent) procedure is intended for locating surface and near surface discontinuities using WET HORIZONTAL / STATIONARY MAGNETIC PARTICLE TESTING MACHINE (suggested/ applicable for Gears, disc, flanges).

2.0 REFERANCE CODES ANS STANDARDS:-

a) ARTICLE 7, ASME SECTION-V,
b) ASTM – A - 275 , SE- 709 .

The codes & standards of latest edition / revision / addenda shall be applicable.

3.0 EXAMINATION PERSONNEL :-

Personnel qualified in accordance with Level-I/ Level-II of ISNT/ASNT shall perform the examination. Testing procedures shall be approved by level-III personnel.

4.0 SURFACE PREPARATION:-

Surface to be tested shall be dry and free from dirt, oil, grease, scale, sand, weld spatter or other extraneous matter.

5.0 EQUIPMENT:-

a) Wet horizontal magnetic particle machine, with HWDC-AC, with min. of 3500Amp range, with fluorescent/visible suspension and 5 / 7 turn coil.
b) Ketos ring, pie-shaped magnetic field indicator/artificial reference standard (or on actual job) with notches/ holes as applicable and Field indicator (Gauss meter).
c) Black light of 1000 micro W/sq. cm intensity (min.) for fluorescent, and a min. light intensity of 100 fc. (1000 Lux) for visible colour contrast test. The intensity of visible light in the darkened area where fluorescent magnetic particles examination is performed should not exceed 2 fc.
d) A 100 ml capacity Pear shaped centrifuge tube with a 1-ml stem (0.05 ml divisions) for fluorescent & with a 1.5-ml stem (0.1ml division) for non-fluorescent suspensions.

6.0 EQUIPMENT CALIBRATION:-

a) Ammeter shall be calibrated at least once a year or when ever equipment has been subjected to major electric repair, periodic overhaul or damage. If ammeter has not been in use for a year or more, calibration shall be done prior to first use.
b) Visible and black light meters shall be calibrated at least once a year or when ever the meter has been repaired, if the meter has not been in use for one year or more, then calibration shall be done before being used.

c) **System performance check**:- The ketos ring specimen shall be used in evaluating and comparing the overall performance and sensitivity of wet, fluorescent and non-fluorescent magnetic particle technique using central conductor technique .The ketos ring is magnetized using central conductor of min. length of 400 mm. The currents used shall be 1400, 2500 and 3500 amps. and the min. no of holes to be detected shall be 3, 5 and 6 respectively when examined with either black light or visible light. This test shall be run at the three amperages if the unit will be used at these or higher amperages. The amperage values stated shall not be exceeded in the test. If the test does not reveal the required number of holes, the equipment shall be taken out of service. This test shall be run at least once per week.

7.0 EXAMINATION METHOD:- Wet (visible/fluorescent)

Examination shall be done by continuous method viz. magnetizing current remains on while the examination medium is being applied and while excess medium is being removed.

8.0 TECHNIQUE:-

8.1. **Central Conductor technique** for circular magnetization position at center of part (for hollow parts).

8.1.1. The current shall be 300 to 800 amp./in. of outer diameter.

8.2. **Off-set Central Conductor/cable wrap technique** for large dia. hollow parts.

8.2.1 The current shall be 300 to 800 amp/in. of job dia., calculated as sum of the dia. of the central conductor and twice the wall thickness of the hollow part.

8.3 **Head Shot technique** (Holding job across O.D).

8.3.1 The current shall be 300 to 800 amp/in. dia. of job.

8.3.2 The current requirements for parts with geometric shapes other than round shall be calculated based on one of the following:

8.3.2.a) Diagonal approach

8.3.2.b) Perimeter approach

The current required for oddly shaped uniform cross sections,

I=P x 1000 /3.1416 I=Current in amperes, P=Perimeter of cross section in cm.

8.4. **Coil technique** for longitudinal magnetization:

8.4.1 For Parts with length over diameter ratio equal to or greater than 4, ampere turns, NI= 35000/ (L/D+2).

8.4.2. For Parts with L/D ratio < 4 but not < 2, ampere turns, NI=45000/(L/D).

Important :-When L/D ratio is less than 2, Coil magnetization technique cannot be used. Then **technique and current** requirements shall be established using artificial reference standard or on actual job with notches / holes /pie-shaped field indicator or as agreed upon.

9.0 EXAMINATION MEDIUM :-

Fluorescent / visible magnetic particle powder of reputed brand with kerosene/water suspension shall be run/agitated through the re circulating system for at least 30 minutes(min.) to ensure thorough mixing and sample be allowed to settle for approx. 60 min. with kerosene or 30 min. with water-based suspensions. The required concentration is 0.1 to 0.4ml for fluorescent particles per 100ml of bath sample and 1.2 to 2.4 ml per 100ml of carrier (vehicle) for non-fluorescent particles. Concentration checks shall be made at least every eight hours. Contamination of carrier & particle shall be checked at least once in a week as per T 765.3 of ASME Sec. V, Article 7.

10.0 EXAMINATION / TEST PROCEDURE :-

Surface to be tested shall be prepared and made suitable for MT. Surface to be tested shall be dry and free from dirt, oil, grease, scale, sand, weld spatter or other extraneous matter.

The intensity of visible light in the darkened area where fluorescent magnetic particles examination is performed should not exceed 2 fc. For visible magnetic particles examination, a min. light intensity of 100 fc. is required on the surface to be examined.

The black light intensity shall be a min. of 1000 micro W/sq. cm on the surface to be examined. The black light intensity shall be verified prior to examination, at least once every 8 hrs., whenever the work station is changed and after completion of examination or series of examinations.

The examination shall be performed in a darkened area. The examiner shall be in darkened area for at least 5 min. prior to performing examination to enable their eyes to adapt dark viewing. If examiner wears glasses or lenses they should not be photo sensitive. The black light shall be allowed to warm up for a minimum of 5 minutes prior to use or measurement of the intensity of UV light emitter to ensure minimum intensity of the UV light shall be done. Reflectors and filters should be checked daily when ever in use. Cracked or broken filters shall be replaced immediately.

The below procedure (which ever is selected /applicable) to be followed:

A) Circular Magnetization (indirect method):

1) Place the central conductor (offset/centrally positioned) /cable wrap inside the hollow part.
2) Use copper braids between the head and central conductor.
3) Tighten/place the central conductor securely to avoid sparks. . Ensure field adequacy using pie-shaped magnetic field indicator/artificial defect standard as applicable by applying required amperage under black /visible light.
4) Magnetize the part by passing current through the central conductor/cable wrap and spray / pour the visible / fluorescent wet magnetic particles simultaneously.
5) The current shall be on while visible / fluorescent wet magnetic particles is being applied.
6) Give two / more shots while visible / fluorescent wet magnetic particles are on the part.

7) Examine the OD/ID surfaces/ magnetized area under visible/black light and record indications.
8) Clean the surface.
9) Test the part by rotating 60, 90, or 180 degree, as the case may be, sufficient for the entire test area with at least 10 percent magnetic field over lap. Rotating shall be 180 degrees for small size of approximately up to 75 mm dia. (The part circumference (exterior) that is effectively magnetized shall be taken as four times the diameter of the central conductor for each position of the part, when central conductor is positioned as offset method.) Repeat step 4 to 8 as above.

OR

B) Circular Magnetization (direct method):

1) Place the object between the contact heads.
2) Use copper braids between the head and job.
3) Tighten the job securely to avoid sparks. Ensure field adequacy using pie-shaped magnetic field indicator/artificial defect standard as applicable by applying required amperage under black /visible light.
4) Magnetize the part by passing current and spray/pour the wet visible/fluorescent magnetic particles simultaneously.
5) The current shall be on while wet visible / fluorescent magnetic particles are being applied.
6) Give two / more shots while wet visible / fluorescent magnetic particles are on the part.
7) Examine the top surface/ magnetized area under black / visible light and record indications.
8) Clean the surface.
9) Test the part by rotating 60, 90, or 180 degree, as the case may be, sufficient for the entire test area with at least 10 percent magnetic field over lap. Rotating shall be 180 degrees for small size of approximately up to 75 mm dia. Repeat steps 4 to 8 as above.

C) Longitudinal Magnetization:

1) Place the component close tot the inside wall of the coil. Ensure field adequacy using pie-shaped magnetic field indicator/artificial defect standard as applicable by applying required amperage under black / visible light .
2) Magnetize the part by passing current and spray / pour the visible / fluorescent wet magnetic particles simultaneously.
3) The current shall be on while visible / fluorescent wet magnetic particles are being applied.

4) Give two / more shots while visible / fluorescent wet magnetic particles are on the part.
5) Examine the top surface/ magnetized area under visible/black light and record indications.
6) Clean the surface.
7) Test the part by rotating 60, 90, or 180 degree ,(for length not exceeding 9 inches on either side of the coil's center , in case of longer length) as the case may be sufficient for the entire test area with at least 10 percent magnetic field over lap. Rotating shall be 180 degrees for small size of approximately up to 75 mm dia. Repeat Steps 2 to 6 as above.

NOTE:-If two current values are used, then start testing with lower currents. The required field strength shall be determined based on length and diameter of the cylindrical part. For non-cylindrical part the length & cross sectional diagonal shall be the basis for determining the required field . Long parts shall be examined in sections, whose length should not exceed 18 in. For calculating the field strength, 18 in. length shall be considered. The ampere-turn shall be as per above clause 8.4.1 & 8.4.2.

11.0 ACCEPTANCE STANDARD:-

All indications shall be evaluated in accordance with acceptance standards of referencing code / technical specification.

12.0 EVALUATION & RECORDING :-

Record all relevant indications, evaluate as per acceptance standard, and report shall be prepared.

13.0 POST-EXAMINATION CLEANING :-

The surfaces of the tested component shall be cleaned properly.

14.0 DEMAGNETIZATION :-

Demagnetization shall be carried out unless otherwise specified. Demagnetize the part and check residual field. If nothing is specified residual flux shall not exceed 3 gauss for general applications and 1 gauss for critical applications as applicable.

15.0 REPORT :-

Complete information shall be reported in enclosed format of MT report.

REPORT FORMAT

MAGNETIC PARTICLE INSPECTION

REPORT No. : DATE:

P. O. No. :

PROCEDURE No. :
DRAWING No. :
COMPONENT NAME & IDENTIFICATION :

STAGE /SURFACE CONDITION OF ITEM :FORGED /ROLLED/CASTING/PROOF / FINISH MACHINED

EQUIPMENT : MAKE: MODEL:
TYPE OF CURRENT ,RANGE : CURRENT: HWDC /AC AMP. RANGE : CALIBRATION DATE:
BLACK LIGHT MAKE/ INTENSITY : CALIBRATION DATE :
TECHNIQUE |: A) LONG.: COIL B) CIRCULAR : HEAD SHOT/CENTRAL
NO.OF TURNS : CONDUCTOR (OFFSET/CENTRAL)
: CURRENT : KAT CURRENT : AMP.

METHOD , PARTICLE TYPE, MAKE : CONTINUOUS WET , VISIBLE/FLUORESCENT,
PARTICLE CONCENTRATION : ml per 100ml of WATER/KEROSEN METHOD OF APPLICATION :
REFERANCE /CALIBRATION STANDARDS :PIE-GAUGE/KETOS-RING/ARTIFICIAL DEFECT STANDARD.
SURFACE ENHANCEMENT COATING : USED / NOT USED
ACCEPTANCE STANDARD :

PRE-CLEANIG :

DETAILS OF DISCONTINUITIES :

SL.NO.	TECHNIQUE	INDICATION & SHAPE	SIZE	LOCATION	REMARKS (ACCEPTED/NOT ACCEPTED)

INSPECTED BY REVIEWED BY WITNESSED BY

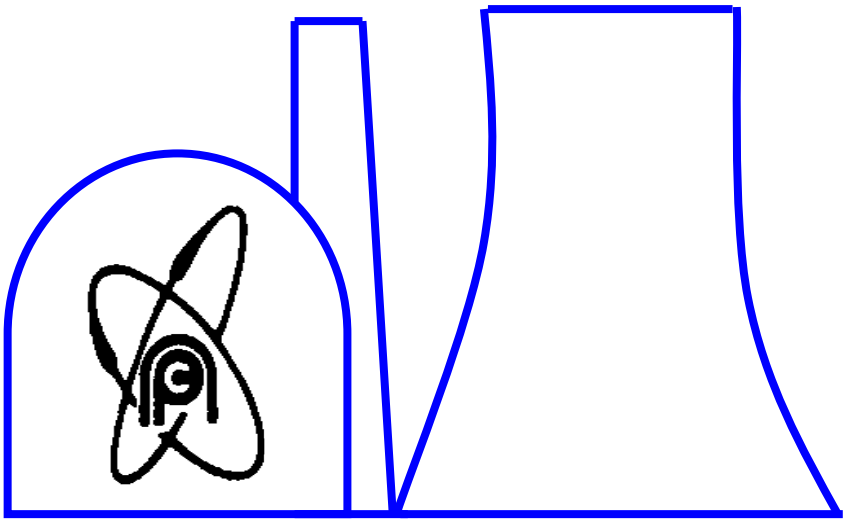
(NAME & NDT QUALIFICATION) (NAME & NDT QUALIFICATION) (NAME & NDT QUALIFICATION)

RECORDING:
POST CLEANING : DONE / NOT DONE
DEMAGNETISATION: DONE / NOT DONE

NOTE:- ALL THE INFORMATION IN THE FORMAT SHOULD BE INCORPORATED AS MINIMUM BY VENDOR FOR REPORTING.

Directorate of Quality Assurance

NDE PROCEDURE



PROCEDURE FOR MAGNETIC PARTICLE TESTING WITH WET HORIZONTAL / STATIONARY MAGNETIC PARTICLE TESTING MACHINE FOR HOLLOW PARTS

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

DOCUMENT NO: QAD/NDT-PROC/MT-04 REV- 2

TITLE	**PROCEDURE FOR MAGNETIC PARTICLE TESTING WITH WET HORIZONTAL / STATIONARY MAGNETIC PARTICLE TESTING MACHINE FOR HOLLOW (ID&OD) PARTS**

This procedure can be used as reference procedure. A "Technique Sheet/Job specific procedure" is to be prepared identifying the NDT process variables and identifying "Acceptance criteria" (NPCIL Specification / Code clause) for a given application by the User/Vendor.

REVISION NO.	**0**	**1**	**2**
DATE OF ISSUE (Month/Year)	**JUNE 2007**	**October 2012**	**August 2017**
TOTAL NO. OF PAGES (Including cover sheet)	**07**	**06**	**10**

REVISION CONTROL SHEET

PROCEDURE FOR MAGNETIC PARTICLE TESTING WITH WET HORIZONTAL / STATIONARY MAGNETIC PARTICLE TESTING MACHINE FOR HOLLOW (ID&OD) PARTS

DOCUMENT NO:QAD/NDT-PROC/MT-04 Rev2

Doc. No. & Date	Description of Revisions		
PP-P-2351 R 0 (June 2007)	Description of Revision: Original		
	Prepared by Y.Sudhakar	Reviewed by A.K.Srivastava	Approved by C.Awasthi
PP-P-2351 R 1 (Oct. 2012)	Description of Revision: Editorial changes and changes as per latest codes/ Standards		
	Revised by Y.Sudhakar	Reviewed by Ranjit Singh	Approved by K.P.Dwivedi
QAD/NDT-PROC/MT-04 Rev2 (August 2017)	Description of Revision: Editorial changes and changes as per latest codes/ Standards		
	Revised by 30.8.17 S.B. Shaik MT-Level – III	Reviewed by 30.08.2017 A.L.V.S.N. Murty MT-Level – III	Approved by 06/9/17 L. K. Jain ED(QA)

1.0 Purpose:

This procedure describes the equipment and methods as well as personnel qualifications essential for the performance of the magnetic particle examination of hollow cylinders, large nuts, pipe couplings, hollow shafts, reducers, elbows and other hollow parts/pipe fittings, where examination of I.D. & OD is done to detect the discontinuities , in accordance with the requirements of ASME Section V Article 7.

2.0 Scope:

This magnetic particle testing(visible/ fluorescent) procedure is intended for locating surface and near surface discontinuities using, WET HORIZONTAL / STATIONARY MAGNETIC PARTICLE TESTING MACHINE (in hollow cylinders, large nuts, pipe couplings, hollow shafts, reducers, elbows and other hollow parts/pipe fittings, where examination of I.D. & OD is possible).

3.0 Reference Documents:

The following codes/standards were referred for this purpose:

a) ASME SECTION-V.
b) ASTM-A-275, SE-709.

4.0 Personnel Qualifications:

a) Personnel performing examination in accordance with this procedure shall be certified at least to Level I/II in MT-ISNT/ASNT.

b) Personnel responsible for data analysis shall be certified to Level II/III in MT-ISNT/ASNT.

5.0 Equipment:

a) Wet horizontal magnetic particle machine, with HWDC-AC, with min. of 3500Amp. range, with fluorescent / visible suspension and 5 / 7 turn coil.
b) Ketos ring, pie-shaped magnetic field indicator, Artificial reference standard with notches/holes or actual job with notches/holes, field indicator (Gauss meter) etc.
c) Black light of 1000 micro W/sq. cm intensity (min.) for fluorescent and a min. light intensity of 100 fc. (1000 Lux) for visible colour contrast test. The intensity of visible light in the darkened area where fluorescent magnetic particles examination is performed should not exceed 2 fc (20 Lux).
d) A 100ml capacity Pear shaped centrifuge tube with a 1-ml stem (0.05 ml divisions) for fluorescent & with a 1.5 ml stem (0.1ml division) for non-fluorescent suspensions.

6.0 Calibration:

a) Ammeter shall be calibrated at least once a year or when ever equipment has been subjected to major electric repair, periodic overhaul or damage. If ammeter has not been in use for a year or more, calibration shall be done prior to first use.

b) Visible and black light meters shall be calibrated at least once a year or whenever the meter has been repaired, if the meter has not been in use for one year or more, then calibration shall be done before being used.

c) **System Performance Check**: The ketos ring specimen shall be used in evaluating and comparing the overall performance and sensitivity of both dry and wet, fluorescent and non-fluorescent magnetic particle technique using central conductor technique .The ketos ring is magnetized using central conductor of min. length of 400 mm. The currents used shall be 1400, 2500 and 3500 amps. and the min. no of holes to be detected shall be 3, 5 and 6 respectively when examined with either black light or visible light. This test shall be run at the three amperages if the unit will be used at these or higher amperages. The amperage values stated shall not be exceeded in the test. If the test does not reveal the required number of holes, the equipment shall be taken out of service. This test shall be run at least once per week.

7.0 Precautions:

Fire hazard: The apparatus/equipment associated with elevated temperatures , in the event of fire , evacuate the room /MT station immediately. Pull the nearest fire alarm.

Ventilation: The test room/MT station shall have proper ventilation such that enough fresh air flows through at all times into the test room/MT station.

Kinetic & Thermal hazard : There are no electrical operated moving parts associated with the equipment during the test, so it does not pose any kinetic treat/risk to the user. The equipment/ MT station is associated with elevated temperatures so it poses thermal treat/risk to the user. The magnetizing current flowing through the test specimen heats up and the user should wear safety gloves to hold the test specimen. User should wear the Safety glasses to protect Eyes from ARCING. Always check for frayed or cut magnetizing cables to prevent any serious burn /injury to the user.

Electrical hazard: Do not, however come into contact with bare cables when they are energized. Keep any electrical/electronic devices clear-off the test area to prevent accidental magnetisation.

Black Light hazard: Avoid using broken / worn filter glass of black-light source during the testing and do not look directly in to UV light.

Please refer to clause no.13 of this procedure for operating experience.

8.0 Examination:

Surface to be tested shall be dry and free from dirt, oil, grease, scale, sand, weld spatter or other extraneous matter.

Examination shall be done by continuous method viz. magnetizing current remains on while the examination medium is being applied and while excess medium is being removed.

Technique:

8.1 Central Conductor Technique for circular magnetization position (Conductor at centre of part):

8.1.1 The current shall be 300 to 800 amp./in. of outer diameter.

8.2 Offset central conductor/cable wrap technique for large dia. hollow parts:

8.2.1 The current shall be 300 t0 800 amp/in. of job dia., calculated as sum of the dia. of the central conductor and twice the wall thickness of the hollow part.

8.3 Head Shot Technique :

8.3.1 The current shall be 300 to 800 amp/in. dia. of job.

8.3.2 The current requirements for parts with geometric shapes other than round shall be calculated based on one of the following:

8.3.2.a) Diagonal approach

8.3.2.b) Perimeter approach

The current required for oddly shaped uniform cross sections,

I=P x 1000 /3.1416 I=Current in amperes, P=Perimeter of cross section in cm.

8.4. Coil Technique for longitudinal magnetization:

8.4.1 For Parts with length over diameter ratio equal to or greater than 4, ampere turns, NI= 35000/ (L/D+2).

8.4.2. For Parts with L/D ratio < 4 but not < 2, ampere turns, NI=45000/(L/D).

Important :-When L/D ratio is less than 2, Coil magnetization technique cannot be used. Then **technique and current** requirements shall be established using artificial reference standard or on actual job with notches / holes /pie-shaped field indicator or as agreed upon.

8.5 Examination Medium:

Fluorescent /visible magnetic particle powder of reputed brand with kerosene/water suspension shall be run/agitated through the re-circulating system for at least 30 minutes(min.) to ensure thorough mixing and sample be allowed to settle for approx. 60 min. with kerosene or 30 min with water-based suspensions. The required concentration is 0.1 to 0.4ml per 100ml of bath sample for fluorescent particles and 1.2 to 2.4 ml per 100 ml of carrier (vehicle) for non-fluorescent particles. Concentration checks shall be made at least every eight hours. Contamination of suspensions shall be checked periodically as per ASME, Sec. V, Article 7 (T-765.3).

8.6 Test Procedure:

Surface to be tested shall be prepared and made suitable for MT. Surface to be tested shall be dry and free from dirt, oil, grease, scale, sand, weld spatter or other extraneous matter.

The intensity of visible light in the darkened area where fluorescent magnetic particles examination is performed should not exceed 2 fc. (20 Lux) for visible magnetic particles examination, a min. light intensity of 100 fc. (1000 Lux) is required on the surface to be examined.

The black light intensity shall be a min. of 1000 micro W/sq. cm on the surface to examined. The black light intensity shall be verified at least once every 8hrs, whenever the work station is changed, or whenever the bulb is changed. The examination shall be performed in darkened area. The examiner shall be in darkened area for at least 5 minutes prior to performing examination to enable their eyes to adapt dark viewing. If examiner wears glasses or lenses they should not be photosensitive. The black light shall be allowed to warm-up for a minimum of 5 minutes prior to use or measurement of the intensity of UV light emitter to ensure minimum intensity of UV Light shall be done. Reflectors & filters should be checked daily when in use. Cracked & broken filters shall be replaced immediately.

Following procedure to be followed :

8.6.1 Circular Magnetization :

1) Place the central conductor (offset/centrally positioned) /cable wrap inside the hollow part.
2) Use copper braids between the head and central conductor.
3) Tighten/place the central conductor securely to avoid sparks. . Ensure field adequacy using pie-shaped magnetic field indicator/artificial defect standard as applicable by applying required amperage under black / visible light.
4) Magnetize the part by passing current through the central conductor/cable wrap and spray /pour the visible / fluorescent wet magnetic particles simultaneously.
5) The current shall be on while visible / fluorescent wet magnetic particles are being applied.
6) Give two / more shots while visible / fluorescent wet magnetic particles are on the part.
7) Examine the OD/ID surfaces/ magnetized area under visible/black light and record indications.
8) Clean the surface.
9) Test the part by rotating 60,90, or 180 degree , as the case may be , sufficient for the entire test area , magnetize and examine with at least 10 percent magnetic field over lap. Rotating shall be 180 degrees for small size of approximately up to 75 mm dia. The part circumference (exterior) that is effectively magnetized shall be taken as four times the diameter of the central conductor for each position of

the part, when central conductor is positioned as offset method. Repeat steps 4 to 8 as above.

8.6.2 Longitudinal Magnetization :

1) Place the component close to the inside wall of the coil. Ensure field adequacy using pie-shaped magnetic field indicator/artificial defect standard as applicable by applying required amperage under black / visible light.
2) Magnetize the part by passing current and spray / pour the visible / fluorescent wet magnetic particles simultaneously.
3) The current shall be on while visible / fluorescent wet magnetic particles are being applied.
4) Give two/ more shots while visible / fluorescent wet magnetic particles are on the part.
5) Examine the top surface/ magnetized area for length not exceeding 9 inches on either side of the coil's centre and examine entire area of the component with at least 10 percent magnetic field overlap under visible/black light and record indications.
6) Clean the surface.
7) Test the part by rotating 60, 90, or 180 degree, as the case may be, sufficient for the entire test area with at least 10 percent magnetic field over lap. Rotating shall be 180 degrees for small size of approximately up to 75 mm dia. Repeat Steps 2 to 6 as above.

NOTE:-If two current values are used, then start testing with lower currents.

The required field strength shall be determined based on length and diameters of the cylindrical part. **For non-cylindrical parts, the length & cross sectional diagonal shall be the basis for determining the required field strength**. Long parts shall be examined in sections, whose length should not exceed 18 inches. 18 inches shall be considered for calculating the field strength. The ampere turns shall be as per above clause no.8.4.1 & 8.4.2.

9.0 Evaluation:

All indications shall be evaluated in terms of the acceptance standards of the referring Code Section/Technical Specification/contract or order.

Discontinuities on or near the surface are indicated by retention of the examination medium. However, localized surface conditions may produce false indications.

Broad areas of particle accumulation, which might mask indications from discontinuities, are prohibited, and such areas shall be cleaned and re-examined.

10.0 Acceptance Criteria:

All indications shall be evaluated in accordance with acceptance standards of referencing code.

The standards for acceptance of defects detected by magnetic particle examination shall be as specified in the applicable Code, ASTM product specification, contract or order.

11.0 Post examination activities:

Demagnetization shall be carried out unless otherwise specified. Demagnetize the part and check residual field. If nothing is specified residual flux shall not exceed 3 gauss for general applications and 1 gauss for critical applications as applicable.

The surfaces of the tested component shall be cleaned properly.

12.0 Records:

Recording of all relevant indications is required to evaluate as per acceptance standard referred in Clause no.10.0. It is also desirable to record indications when parts are tested and retained in use. Techniques that can be used for recording indications are tape transfer, lacquer fixing and photography.

Report shall be prepared as per attached "Annexure" after completion of the magnetic practical inspection.

13.0 Operating Experience:

Experienced NDT personnel are most important in the interpretation & evaluation of Magnetic Particle Testing (MT) indications. Indications revealed by MT provide the evaluator with size, shape and location. The inspector and other personnel involved in the evaluation must have a wide back ground in materials and fabrication technology. They should also have a broad knowledge of metals production, a basic understanding of metallurgy, a knowledge of metal working and manufacturing methods and experience in the behaviour of different metals in service.

In addition, inspection personnel must have good eyesight because the indication must first be seen to be detected. Inspectors must be conscious and have temperament to with stand the boredom of testing many parts with out becoming careless. After many parts have been tested with out detecting a discontinuity, it is a natural human tendency to become less alert. Shop floor NDT inspector must be aware of such factors, have lot of patience and be alert.

Annexure

REPORT FORMAT

MAGNETIC PARTICLE INSPECTION REPORT

REPORT NO. : DATE:

PO.NO. :

PROCEDURE NO. :
DRAWING NO. :
COMPONENT NAME & IDENTIFICATION :

STAGE /SURFACE CONDITION OF ITEM : FORGED/ROLLED/CASTING/PROOF / FINISH MACHINED

EQUIPMENT : MAKE: MODEL:
TYPE OF CURRENT ,RANGE : CURRENT: HWDC /AC AMP. RANGE : CALIBRATION DATE:
BLACK LIGHT MAKE/ INTENSITY : CALIBRATION DATE :
TECHNIQUE : A) LONG.: COIL B) CIRCULAR : CENTRAL CONDUCTOR/
NO.OF TURNS : (OFF-SET/CENTRAL) HEAD SHOT
CURRENT : KAT: CURRENT : AMP.

METHOD , PARTICLE TYPE,MAKE : CONTINUOUS WET , VISIBLE/FLUORESCENT,
PARTICLE CONCENTRATION : ml per 100ml of WATER/KEROSEN METHOD OF APPLICATION :
REFERANCE /CALIBRATION STANDARDS :PIE-GAUGE/KETOS-RING/ARTIFICIAL DEFECT STRD.
SURFACE ENHANCEMENT COATING : USED / NOT USED
ACCEPTANCE STANDARD :

PRE-CLEANIG :

DETAILS OF DISCONTINUITIES :

SL.NO.	TECHNIQUE	INDICATION	SIZE & SHAPE	LOCATION	REMARKS (ACCEPTED/ NOT ACCEPTED)

INSPECTED BY REVIEWED BY WITNESSED BY

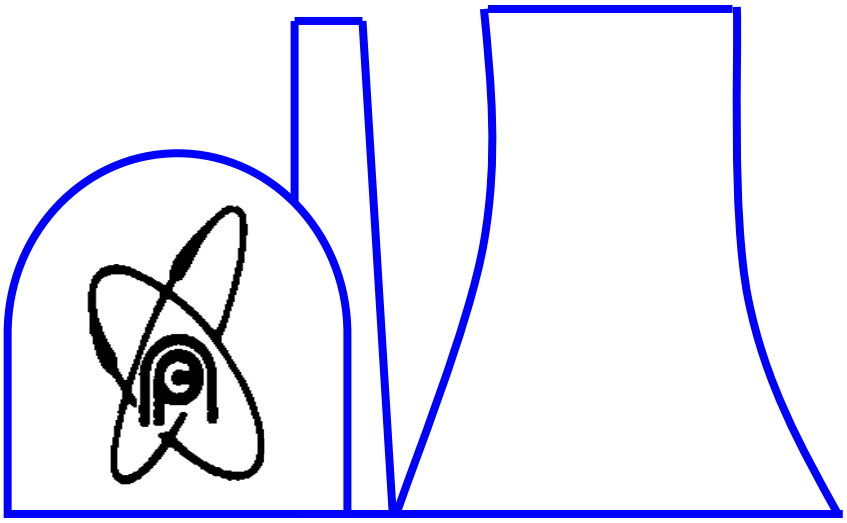
(NAME &NDT QUALIFICATION) (NAME & NDT QUALIFICATION) (NAME & NDT QUALIFICATION)

RECORDING:
POST CLEANING : DONE / NOT DONE
DEMAGNETISATION: DONE / NOT DONE

NOTE:- ALL THE INFORMATION IN THE FORMAT SHOULD BE INCORPORATED AS MINIMUM BY VENDOR FOR REPORTING.

Directorate of Quality Assurance

NDE PROCEDURE



PROCEDURE FOR MAGNETIC PARTICLE TESTING WITH WET HORIZONTAL / STATIONARY MAGNETIC PARTICLE TESTING MACHINE

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

DOCUMENT NO.: QAD/NDT-PROC/MT-05, REV-2

TITLE	PROCEDURE FOR MAGNETIC PARTICLE TESTING WITH WET HORIZONTAL / STATIONARY MAGNETIC PARTICLE TESTING MACHINE

This procedure can be used as reference procedure. A "Technique Sheet/Job specific procedure" is to be prepared identifying the NDT process variables and identifying "Acceptance criteria" (NPCIL Specification / Code clause) for a given application by the User/Vendor.

REVISION NO.	0	1	2
DATE OF ISSUE (Month/Year)	June 2007	October 2012	August 2017
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REVISION CONTROL SHEET

DOCUMENT No.QAD/NDT-PROC/MT/05, REV-2

PROCEDURE FOR MAGNETIC PARTICLE TESTING WITH WET HORIZONTAL / STATIONARY MAGNETIC PARTICLE TESTING MACHINE

Doc. No. & Date	Description of Revisions		
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	Revised By **Y. Sudhakar**	**Reviewed by** **Ranjit Singh**	**Approved by** **K. P. Dwivedi**
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1.0 Purpose:

This procedure describes the equipment and methods as well as personnel qualifications essential for the performance of the magnetic particle examination of finish machined components/solid bars/components made of forgings or rolled bars, castings, shafts , pinions, bolts, billets and tubes/pipes/hollow shafts (in case of only OD to be examined) to detect the discontinuities in accordance with the requirements of ASME Section V Article 7.

2.0 Scope:

This magnetic particle testing (visible/ fluorescent) procedure is applicable to locating surface and near surface discontinuities for finish machined components/solid bars/components made of forgings or rolled bars, castings, shafts , pinions, bolts, billets and tubes/pipes/hollow shafts (in case of only OD to be examined) using WET HORIZONTAL / STATIONARY MAGNETIC PARTICLE TESTING MACHINE .

3.0 Reference Documents:

The following codes/standards were referred for this purpose:

a) ASME SECTION-V.
b) ASTM-A-275, SE-709.

The codes and standards of latest edition / revision / addenda shall be applicable.

4.0 Personnel Qualifications:

a) Personnel performing examination in accordance with this procedure shall be certified at least to Level I/II in MT-ISNT/ASNT.

b) Personnel responsible for data analysis shall be certified to Level II/III in MT-ISNT/ASNT.

5.0 Equipment:

a) Wet horizontal magnetic particle machine, with HWDC-AC, with min. of 3500Amp. range, with fluorescent / visible suspension and 5 / 7 turn coil.
b) Ketos ring, pie-shaped magnetic field indicator, Artificial reference standard with notches/holes or actual job with notches/holes, field indicator (Gauss meter) etc.
c) Black light of 1000 micro W/sq. cm intensity (min.) for fluorescent and a min. light intensity of 100 fc. (1000 Lux) for visible colour contrast test. The intensity of visible light in the darkened area where fluorescent magnetic particles examination is performed should not exceed 2 fc (20 Lux).
d) A 100ml capacity Pear shaped centrifuge tube with a 1-ml stem (0.05 ml divisions) for fluorescent & with a 1.5 ml stem (0.1ml division) for non-fluorescent suspensions.

6.0 Calibration:

a) Ammeter shall be calibrated at least once a year or when ever equipment has been subjected to major electric repair, periodic overhaul or damage. If ammeter has not been in use for a year or more, calibration shall be done prior to first use.

b) Visible and black light meters shall be calibrated at least once a year or whenever the meter has been repaired, if the meter has not been in use for one year or more, then calibration shall be done before being used.

c) **System Performance Check**: The ketos ring specimen shall be used in evaluating and comparing the overall performance and sensitivity of both dry and wet, fluorescent and non-fluorescent magnetic particle technique using central conductor technique .The ketos ring is magnetized using central conductor of min. length of 400 mm. The currents used shall be 1400, 2500 and 3500 amps. and the min. no of holes to be detected shall be 3, 5 and 6 respectively when examined with either black light or visible light. This test shall be run at the three amperages if the unit will be used at these or higher amperages. The amperage values stated shall not be exceeded in the test. If the test does not reveal the required number of holes, the equipment shall be taken out of service. This test shall be run at least once per week.

7.0 Precautions:

Fire hazard: The apparatus/equipment associated with elevated temperatures , in the event of fire , evacuate the room /MT station immediately. Pull the nearest fire alarm.

Ventilation: The test room/MT station shall have proper ventilation such that enough fresh air flows through at all times into the test room/MT station.

Kinetic & Thermal hazard : There are no electrical operated moving parts associated with the equipment during the test, so it does not pose any kinetic treat/risk to the user. The equipment/ MT station is associated with elevated temperatures so it poses thermal treat/risk to the user. The magnetizing current flowing through the test specimen heats up and the user should wear safety gloves to hold the test specimen. User should wear the Safety glasses to protect Eyes from ARCING. Always check for frayed or cut magnetizing cables to prevent any serious burn /injury to the user.

Electrical hazard: Do not, however come into contact with bare cables when they are energized. Keep any electrical/electronic devices clear-off the test area to prevent accidental magnetisation.

Black Light hazard: Avoid using broken / worn filter glass of black-light source during the testing and do not look directly in to UV light.

Please refer to clause no.13 of this procedure for operating experience.

8.0 Examination:

Surface to be tested shall be dry and free from dirt, oil, grease, scale, sand, weld spatter or other extraneous matter.

Examination shall be done by continuous method viz. magnetizing current remains on while the examination medium is being applied and while excess medium is being removed.

8.1 Head Shot Technique for circular magnetization:

8.1.1 The current shall be 300 to 800 amp./in. of outer diameter.

8.1.2 The current requirements for parts with geometric shapes other than round shall be calculated based on one of the following:

a) Diagonal approach

b) Perimeter approach

The current required for oddly shaped uniform cross-sections,
I=P X 1000 /3.1416, where, I = current in amperes,
P = perimeter of cross- section in cm.

8.2 Coil Technique for longitudinal magnetization:

8.2.1 For Parts with length over diameter ratio equal to or greater than 4, ampere turns, NI= 35000/ (L/D+2).

8.2.2 For Parts with L/D ratio < 4 but not < 2, ampere turns, NI=45000/(L/D).

Important:- When L/D ratio is less than 2, Coil magnetization technique cannot be used. Then **technique and current** requirements shall be established using artificial reference standard or on actual job with notches/ holes/ pie-shaped field indicator or as agreed upon.

8.3 Examination medium:

Fluorescent /visible magnetic particle powder of reputed brand with kerosene/water suspension shall be run/agitated through the re-circulating system for at least 30 minutes(min.) to ensure thorough mixing and sample be allowed to settle for approx. 60 min. with kerosene or 30 min with water-based suspensions. The required concentration is 0.1 to 0.4ml per 100ml of bath sample for fluorescent particles and 1.2 to 2.4 ml per 100 ml of carrier (vehicle) for non-fluorescent particles. Concentration checks shall be made at least every eight hours. Contamination of suspensions shall be checked periodically as per ASME Sec.V, Article 7 (T-765.3).

8.4. Test Procedure:

Surface to be tested shall be prepared and made suitable for MT. Surface to be tested shall be dry and free from dirt, oil, grease, scale, sand, weld spatter or other extraneous matter.

The intensity of visible light in the darkened area where fluorescent magnetic particles examination is performed should not exceed 2 fc (20 Lux). For visible magnetic

particles examination, a min. light intensity of 100 fc (1000 Lux) is required on the surface to be examined.

The black light intensity shall be a min. of 1000 micro W/sq. cm on the surface to examined. The black light intensity shall be verified at least once every 8hrs, whenever the work station is changed, or whenever the bulb is changed. The examination shall be performed in darkened area. The examiner shall be in darkened area for at least 5 minutes prior to performing examination to enable their eyes to adapt dark viewing. If examiner wears glasses or lenses they should not be photosensitive. The black light shall be allowed to warm-up for a minimum of 5 minutes prior to use or measurement of the intensity of UV light emitter to ensure minimum intensity of UV Light shall be done. Reflectors & filters should be checked daily when in use. Cracked & broken filters shall be replaced immediately.

Following procedure to be followed :

8.4.1 Circular magnetization :

a. Place the object between the contact heads.
b. Use copper braids between the head and job.
c. Tighten the job securely to avoid sparks. Ensure field adequacy using pie-shaped magnetic field indicator/artificial defect standard as applicable by applying required amperage under black / visible light.
d. Magnetize the part by passing current and spray /pour the visible / fluorescent wet magnetic particles simultaneously.
e. The current shall be on while visible / fluorescent wet magnetic particles are being applied.
f. Give two / more shots while visible / fluorescent wet magnetic particles are on the part.
g. Examine the top surfaces/ magnetized area under visible/black light and record indications.
h. Clean the surface.
i. Test the part by rotating 60, 90, or 180 degree , as the case may be , sufficient for the entire test area and examine with at least 10 percent over lap. Rotating shall be 180 degrees for small size of approximately up to 75 mm dia.. Repeat steps 4 to 8 as above.

8.4.2 Longitudinal magnetization:-

a. Place the component close to the inside wall of the coil. Ensure field adequacy using pie-shaped magnetic field indicator/artificial defect standard as applicable by applying required amperage under black / visible light.
b. Magnetize the part by passing current and spray / pour the visible / fluorescent wet magnetic particles simultaneously.
c. The current shall be on while visible / fluorescent wet magnetic particles are being applied.

d. Give two/ more shots while visible / fluorescent wet magnetic particles are on the part.
e. Examine the top surface/ magnetized area for length not exceeding 9 inches on either side of the coil's centre and examine entire area of the component with at least 10 percent overlap under visible/black light and record indications.
f. Clean the surface.
g. Test the part by rotating 60, 90, or 180 degree, as the case may be, sufficient for the entire test area with at least 10 percent over lap. Rotating shall be 180 degrees for small size of approximately up to 75 mm dia. Repeat Steps 2 to 6 as above.

NOTE:-If two current values are used, then start testing with lower currents.

The required field strength shall be determined based on length and diameters of the cylindrical part. **For non-cylindrical parts the length & cross sectional diagonal shall be the basis for determining the required field strength**. Long parts shall be examined in sections whose length should not exceed 18 inches. For calculating the field strength, 18 inches length shall be considered. The ampere turns shall be as per above clause no.8.2.1 & 8.2.2.

9.0 Evaluation:

All indications shall be evaluated in terms of the acceptance standards of the referring Code Section/Technical Specification/contract or order.

Discontinuities on or near the surface are indicated by retention of the examination medium. However, localized surface conditions may produce false indications.

Broad areas of particle accumulation, which might mask indications from discontinuities, are prohibited, and such areas shall be cleaned and re-examined.

10.0 Acceptance Criteria:

All indications shall be evaluated in accordance with acceptance standards of referencing code/Technical Specification/contract or order.

11.0 Post-examination activities:

Demagnetization shall be carried out unless otherwise specified. Demagnetize the part and check residual field. If nothing is specified residual flux shall not exceed 3 gauss for general applications and 1 gauss for critical applications as applicable.

The surfaces of the tested component shall be cleaned properly.

12.0 Records:

Recording of all relevant indications is required to evaluate as per acceptance standard referred in Clause no.10.0. It is also desirable to record indications when parts are tested and retained in use. Techniques that can be used for recording indications are tape transfer, lacquer fixing and photography.

Report shall be prepared as per attached "Annexure" after completion of the magnetic practical inspection.

13.0 Operating Experience:

Experienced NDT personnel are most important in the interpretation & evaluation of Magnetic Particle Testing (MT) indications. Indications revealed by MT provide the evaluator with size, shape and location. The inspector and other personnel involved in the evaluation must have a wide back ground in materials and fabrication technology. They should also have a broad knowledge of metals production, a basic understanding of metallurgy, a knowledge of metal working and manufacturing methods and experience in the behaviour of different metals in service.

In addition, inspection personnel must have good eyesight because the indication must first be seen to be detected. Inspectors must be conscious and have temperament to with stand the boredom of testing many parts with out becoming careless. After many parts have been tested with out detecting a discontinuity, it is a natural human tendency to become less alert. Shop floor NDT inspector must be aware of such factors, have lot of patience and be alert.

Annexure

REPORT FORMAT

MAGNETIC PARTICLE INSPECTION REPORT

REPORT NO. : DATE:

PO.NO. :

PROCEDURE NO. :
DRAWING NO. :
COMPONENT NAME & IDENTIFICATION :

STAGE /SURFACE CONDITION OF ITEM : FORGED/ROLLED/CASTING/PROOF / FINISH MACHINED

EQUIPMENT : MAKE: MODEL:
TYPE OF CURRENT ,RANGE : CURRENT: HWDC /AC AMP. RANGE : CALIBRATION DATE:
BLACK LIGHT MAKE/ INTENSITY : CALIBRATION DATE :
TECHNIQUE |: A) LONG.: COIL B) CIRCULAR : HEAD SHOT
NO.OF TURNS :
CURRENT : KAT: CURRENT : AMP.

METHOD , PARTICLE TYPE,MAKE : CONTINUOUS WET , VISIBLE/FLUORESCENT,
PARTICLE CONCENTRATION : ml per 100ml of WATER/KEROSEN METHOD OF APPLICATION :
REFERANCE /CALIBRATION STANDARDS :PIE-GAUGE/KETOS-RING/ARTIFICIAL DEFECT STRD.
SURFACE ENHANCEMENT COATING : USED / NOT USED
ACCEPTANCE STANDARD :

PRE-CLEANIG :

DETAILS OF DISCONTINUITIES :

SL.NO.	TECHNIQUE	INDICATION	SIZE & SHAPE	LOCATION	REMARKS (ACCEPTED/ NOT ACCEPTED)

INSPECTED BY REVIEWED BY WITNESSED BY

(NAME &NDT QUALIFICATION) (NAME & NDT QUALIFICATION) (NAME & NDT QUALIFICATION)

RECORDING:
POST CLEANING : DONE / NOT DONE
DEMAGNETISATION: DONE / NOT DONE

NOTE:- ALL THE INFORMATION IN THE FORMAT SHOULD BE INCORPORATED AS MINIMUM BY VENDOR FOR REPORTING.

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

DOCUMENT NO: QAD/NDT-PROC/PT-01 REV- 2

TITLE	PROCEDURE FOR LIQUID PENETRANT EXAMINATION (COLOUR CONTRAST SOLVENT REMOVABLE TYPE)

This procedure can be used as reference procedure. A "Technique Sheet/Job specific procedure" is to be prepared identifying the NDT process variables and identifying "Acceptance criteria" (NPCIL Specification / Code clause) for a given application by the User/Vendor.

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REVISION CONTROL SHEET

PROCEDURE FOR LIQUID PENETRANT EXAMINATION (COLOUR CONTRAST SOLVENT REMOVABLE TYPE) DOCUMENT NO: QAD/NDT-PROC/PT-01 R2

Rev. No. & Date	Description of Revisions		
PP-E-2397 R 0 (June. 2007)	Description of Revision: Original		
	Prepared by P.M. Shah	Reviewed by S.K. Agrawal	Approved by A.K. Shrivastava
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	Revised by N.P.Upadhyay	Reviewed by Sundar Singh	Approved by K.P.Dwivedi
QAD/NDT-PROC/ PT-01 R2 (Oct. 2017)	Description of Revision: Editorial changes and changes as per latest ASME codes (2015 edition). Refer sheet no. 3 for details.		
	V K Agarwal PT-Level – III ACE (QA)	J K Jain PT-Level – III AD(QA) Group-II	L K Jain ED(QA)

Summery sheet of changes carried out in Revision-02

1. Cover page is modified.
2. Index page is introduced.
3. Title 'Purpose' is added.
4. Scope is modified. Annexure-1 is added for giving job details.
5. In clause no. 3.0, Applicable documents are added.
6. In clause no. 4.0, Procedure qualification is added.
7. Clause no.6.0 is added for calibration requirement of light meter.
8. Clause no.8.5, Warning is added for personal safety.
9. Clause no.10.0 is modified. It is added that acceptance criteria is only for reference. User should select according to job/code requirement.
10. Clause no.12.0 is modified; Methods of recording of indications added. It is added that report shall be signed by Level-II qualified personnel.
11. Clause no.11.0 is modified; Importance of post cleaning is highlighted.
12. Table no.1 is added containing Essential & nonessential variables.
13. Table no.3 is modified. Temperature range and dwell time is changed.
14. Annexure-1 is added giving details of job.
15. Annexure-2 (Format for Report) is modified for better clarity.

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1.0 PURPOSE:

1.1 This procedure describes the equipment and methods as well as the personnel qualifications essential for the performance of liquid penetrant examination of non-porous ferrous, non-ferrous and non-metallic materials such as fully densified ceramics, plastics, glass, etc using colour contrast solvent removable Penetrant test method.

2.0 SCOPE:

2.1 This procedure describes the requirements & acceptance criteria for liquid penetrant examination of non-porous ferrous, non-ferrous and non-metallic materials such as fully densified ceramics, plastics, glass, etc using colour contrast solvent removable Penetrant test method. Refer enclosed Annexure-1 for job details (product form, material, shape, size, extent of examination & quantity). Acceptance criteria will be in accordance with applicable PO/drawing/code/standard.

2.2 Typical surface discontinuities detectable by this method are cracks, seams, laps, cold shuts, porosity, laminations etc.

3.0 REFERENCE DOCUMENTS :

a. P.O. No…… (as applicable)
b. Drawing (as applicable)
c. ASME Section-V, Article-6 (Latest edition),
d. ASME Section-V, Article 24, SE-165(Latest edition)
e. ASME Sec VIII Div I/Div II (as applicable)
f. ASME Sec. III NB/NC/ND (as applicable)

4.0 PERSONNEL & PROCEDURE QUALIFICATION:

4.1 PERSONNEL QUALIFICATION :

Personnel performing non-destructive examination and evaluation shall be qualified in accordance with written procedure conforming to the recommended practice IS-

13805/ISO-9712-3/SNT-TC-1A or any other recognized practice agreed with customer.

4.2 PROCEDURE QUALIFICATION :

Qualification of procedure using dwell times or condition different from those specified or for new materials shall be re-qualified. Refer table-1 for essential and not essential variables for guidance.

5.0 EQUIPMENTS (PENETRANT MATERIALS) :

- Cleaner.
- Penetrant.
- Developer.
- Lint free cloth.
- Lighting equipment of minimum illumination of 1000 Lux.

5.1 For nickel base alloys and for stainless steel materials the penetrant materials such as cleaner, penetrant, developer, etc., used shall not contain sulphur or halogen above 25 PPM. Only NPC approved penetrant material shall be used for testing. Latest list of approved brand of NDT material should be obtained from QA Directorate, NPCIL, Mumbai.

5.2 Selection of liquid penetrant materials shall be from the same family (brand). Inter-mixing of family of liquid penetrant materials is not permitted.

6.0 CALIBRATION :

6.1 Adequate illumination is required to ensure no loss of the sensitivity in the examination. Examination shall be done under natural or suitable light. Illumination level shall be minimum 1000 LUX (100 fc) on the surface being tested. Light meter shall be calibrated at least once a year or whenever the meter has been repaired prior to use.

7.0 PRECAUTIONS :

The vapours from Cleaner, Penetrant and Developer may be hazardous. Proper ventilation should be provided & face mask should be used for breathing.

8.0 EXAMINATION :

8.1 SURFACE PREPARATION :

8.1.1 Surface preparation by grinding, machining or other suitable method may be employed where surface irregularities may mask indications.

8.1.2 The surface to be examined and all adjacent areas within at least 25 mm shall be dry and free from any dirt, lint, scale, rust, welding flux, weld spatter, grease, oil etc. These extraneous matters could obscure surface openings or otherwise interfere with examination.

8.1.3 The surface to be examined shall be cleaned with detergents, organic solvents, de-scaling solutions or paint removers. Degreasing and ultrasonic cleaning may be employed to increase cleaning efficiency. Cleaning method employed is an important part of the examination procedure. Cleaning solvents shall meet the requirement of Clause 5.1.

Table-2 may be used as guideline for selection of surface preparation method.

Caution: Blasting with shots or dull sand, buffing, wire brushing the soft material or machining with dull tools shall not be used as they may peen the discontinuities at the surface. When it is found necessary to use abrasive treatments, a chemical etching shall be followed to reopen surface discontinuities.

8.2 PRE CLEANING & DRYING :

Surface to be examined shall be cleaned thoroughly by solvent before application of penetrant. Drying shall be accomplished by normal evaporation or with forced hot air, as appropriate. A minimum period of time shall be established to ensure that the cleaning solution has evaporated prior to application of the penetrant.

8.3 APPLICATION OF PENETRANT :

8.3.1 The penetrant shall be applied by dipping, brushing or spraying. If the penetrant is applied by spraying using compressed air type apparatus, filters shall be placed at the air inlet to preclude contamination of the penetrant by oil, water, dirt or sediment that may have collected in the lines. Spraying should only be performed in a booth equipped with exhaust system.

8.3.2 The duration of penetrant time (dwell time) is critical and depends upon the material being inspected, the process through which it has passed and the type of discontinuities expected. The recommended (dwell) times are given in **Table 3.**

8.3.3 The temperature of the penetrant and the surface of the part to be examined shall not be below 5 deg C and not above 52 deg C throughout the examination period. Where it is not practical to comply with these temperature limitations, other temperatures and times shall be used provided the procedure is qualified.

8.4 REMOVAL OF EXCESS PENETRANT & CLEANING :

8.4.1 After the penetration time specified in the procedure has elapsed, any penetrant remaining on the surface shall be removed, taking care to minimize removal of penetrant from discontinuities.

8.4.2 Excess penetrant shall be removed by wiping with a lint free cloth or absorbent paper. Repeat the operation until most traces of penetrant have been removed. The remaining traces shall be removed by wiping the surface lightly with cloth or absorbent paper moisturized with solvent.

Caution: Care shall be taken to avoid use of excess solvent as this may remove penetrant from discontinuities. Flushing the surface with solvent, following the application of the penetrant and prior to developing, is prohibited.

6.4.3 Surface shall be dried before the application of developer. For this method, the surface may be dried by normal evaporation, blotting, wiping or forced air. If the surface remains in dried condition for more than 30 minutes, it may impair the sensitivity of the examination.

8.5 APPLICATION OF DEVELOPER :

8.5.1 The developer shall be applied as soon as possible after the removal of the excess penetrant and after drying as required. With colour contrast penetrant, only wet developer shall be used.

8.5.2 Prior to applying suspension type wet developer to the surface, the developer must be thoroughly agitated to ensure adequate dispersion of suspended particles.

(a) Aqueous Developer Application:

Aqueous developer may be applied to either a wet or dry surface. It shall be applied by dipping, spraying or other means provided a thin coating is obtained over the entire surface being examined.

(b) Non-aqueous Developer Application:

Non-aqueous developer shall be applied (after drying of surface being tested) by spraying, except where safety or restricted access precludes it. Under such conditions developer may be applied by brushing. Drying shall be by normal evaporation.

Warning: The vapour from evaporation, volatile solvent developer carrier may be hazardous. Proper ventilation should be provided & face mask should be used for breathing.

8.6 Post Cleaning :

Post cleaning shall be carried out immediately after the evaluation & interpretation of test results.

9.0 EVALUATION:

9.1 Observe the surface during the application of the developer to detect nature of any indications which tend to bleed out profusely. Final examination shall be done between 10 minutes at the earliest and 30 minutes at the latest after application of the developer. The nature of discontinuities corresponding to the indications shall be defined depending upon the method of setting, appearance, direction, shape and dimensions of the same. If the bleed out does not alter the examination results, longer periods are permitted. If the surface to be examined is large enough to preclude complete examination within the prescribed time, the surface shall be examined in increments.

9.2 With colour contrast penetrant, the developer forms a reasonably uniform coating. Surface discontinuities are indicated by bleeding out of the penetrant which is normally of a deep red colour. Indication with a light pink colour may indicate excessive cleaning. Inadequate cleaning may leave an excessive background making interpretation difficult.

9.3 As the developer dries to a smooth, even white coating, indications will appear at the locations of discontinuities. Depth of surface discontinuities may be correlated with the richness of colour and speed of bleeding out. However, localized surface imperfections such as from machining marks or surface conditions may produce similar indications which are non-relevant.

9.4 Usually, a crack or similar opening will show a line and light cracks or partially welded lap will show a broken line. Gross porosity may produce large indications covering an entire area. Very fine porosity is indicated by random dots.

9.5 Any non-relevant indication shall be regarded as a defect until the indication is either eliminated by surface conditioning or it is proved non-relevant by other NDT methods.

9.6 Linear indications are those indications in which the length is more than three times the width. Rounded indications are indications which are circular or elliptical with the length equal to or less than three times the width.

9.7 All indications shall be evaluated in terms of the acceptance standards of the referencing documents.

10.0 ACCEPTANCE CRITERIA (for reference & guidance only):

Acceptance criteria of the indications are as per the acceptance norms as specified in PO specification/Technical Specification/Drawing/ Data Sheet etc, as applicable. Following acceptance standards are given for reference (for welds). Applicable standards shall be followed for casting, Forging and wrought materials etc.

10.1 ASME Sec. VIII Div.I/II (Edition 2015)

a) Only imperfections producing indications with major dimensions greater than 1/16 in (1.5mm) shall be considered to be relevant imperfections.

b) All surfaces to be examined shall be free of relevant linear indications.

c) Relevant rounded indication greater than 3/16 in (5 mm) shall not be acceptable.

d) Four or more relevant rounded indications in a line separated by 1/16 in (1.5mm) or less (edge to edge), shall not be acceptable.

e) Crack like indications detected, irrespective of surface conditions, are unacceptable

10.2 ASME Sec-III-NB/NC/ND (Edition 2015)

a) Only imperfections producing indications with major dimensions greater than 1/16 in (1.5mm) shall be considered to be relevant imperfections.

b) Imperfections producing the following indications are unacceptable:

1) Any cracks or linear indications;

2) Rounded indications with dimensions greater than 3/16 in. (5 mm);

3) Four or more rounded indications in a line separated by 1/16 in (1.5mm) or less edge to edge;

4) Ten or more rounded indications in any 6 sq in of surface with the major dimension of this area not to exceed 6 in. (150mm) with the area taken in the most unfavourable location relative to the indications being evaluated.

11.0 POST EXAMINATION ACTIVITIES :

Surfaces examined shall be cleaned thoroughly after evaluation of the test with dry cotton cloth with or without solvent. This is more important in austenitic SS, titanium, nickel based or high temperature alloys. Impurities present in penetrant materials such as sulphur, halogens and alkali may cause embrittlement or corrosion.

12.0 RECORD OF EXAMINATION (FORMAT OF REPORT):

Record for each examination shall be prepared in a format, attached with this procedure as Annexure-2. The type of indications (linear or rounded), location and extent (length or diameter or aligned) shall be recorded. Cello tapes, sketches or photographs can be used for recording the indications.

Report shall be signed by at least level-II qualified personnel.

13.0 OPERATING EXPERIENCE :

13.1 It is observed that most qualified personals are unaware about importance of pre cleaning of the surface before conducting PT examination and clean the surface by means of shot blasting, buffing, wire brushing the soft material or machining the surface with dull tools. These shall not be used as they may peen the discontinuities at the surface. When it is found necessary to use abrasive treatments, a chemical etching shall be followed to reopen surface discontinuities.

13.2 It is noted that some of private companies employ only one qualified personal. Generally job is performed by unqualified personals, who do not understand the procedure requirements. The sensitivity of PT examination is greatly influenced by followings:

- Inadequate pre cleaning of surface.
- Under cleaning or over cleaning of surface after completion of dwell time.
- Cleaning the surface in time less than specified dwell period or in time much more than specified dwell period.
- Evaluating the test results before completion of specified development time.

In view of this, it is recommended that PT examination should always be performed by at least level-I qualified personal only.

13.3 Persons performing PT examination do not take adequate personnel protection. Penetrant used for testing contains different types of chemicals which may be hazardous for skin and lungs, if inhaled. Therefore hand gloves should be used, proper ventilation should be maintained & mask should be used for breathing.

TABLE -1

REQUIREMENTS OF LIQUID PENETRANT EXAMINATION PROCEDURE

Sl No.	Requirement	Essential Variable	Nonessential Variable
1.	Identification of and any change in type or family group of penetrant materials including developers etc.	X	-----
2.	Surface preparation (finishing and cleaning, including type of cleaning solvent).	X	-----
3.	Method of applying penetrant.	X	-----
4.	Method of removing excess surface penetrant.	X	-----
5.	Method of applying developer.	X	-----
6.	Minimum and maximum time periods between steps and drying aids.	X	-----
7.	Decrease in penetrant dwell time.	X	-----
8.	Increase in developer dwell time. (Interpretation	X	-----

	Time)		
9.	Minimum light intensity.	X	-----
10.	Surface temperature outside 40°F to 125°F (5°C to 52°C) or as previously qualified.	X	-----
11.	Performance demonstration, when required.	X	-----
12.	Personnel qualification requirements.	-----	X
13.	Materials, shapes, or sizes to be examined and the extent of examination.	-----	X
14.	Post-examination cleaning technique.	-----	X

'X' means- applicable

TABLE -2

APPLICABLE METHODS FOR SURFACE PREPARATION

Product	Surface preparation
Weld	Wire brushing, Grinding, Solvent cleaner
Machined Component	Solvent cleaner, Degreasing, Ultrasonic cleaning
Fittings/ Forgings	Grindings, Machining, Solvent cleaning, Degreasing
Castings	Grinding, Sand blasting, Shot blasting
Non- ferrous Material	Machining, Grinding, Solvent cleaning
Non metal	Solvent cleaning, Degreasing, Detergent cleaning

TABLE -3

RECOMMENDED MINIMUM DWELL TIMES

Material	Material Form	Type of Discontinuity	Dwell Times # (Minutes)

			Penetrant	Developer
Aluminium, magnesium, Steel, brass and bronze, titanium and high temperature alloys	Castings and welds	Cold shuts, porosity, lack of fusion, cracks (All forms)	5	10
	Wrought materials – extrusions, forgings, plate	Laps, Cracks (all forms)	10	20
Carbide-tipped tools	Brazed or welded	Lack of fusion, Porosity, cracks	5	10
Plastic	All forms	Cracks	5	10
Glass	All forms	Cracks	5	10
Ceramic	All forms	Cracks, porosity	5	10

Dwell time given is for temperature range from 10°C to 52°C. For temperature range between 5°C to 10°C, recommended minimum dwell time is 20 minutes.

Development time begins as soon as wet developer coating has dried on surface of parts (Recommended minimum).

Annexure-1

Job Details (Product form, material, Shape, Size, extent of examination & Quantity)

Annexure-2

FORMAT FOR REPORT

Manufacturer Name & Address

Report for Dye Penetrant Examination

Report No. :
Date :

Procedure No & Rev:					
Manufacture Ref. No.: (Package contractor/main vendor/sub-vendor/supplier)					
P.O. No / Sub order No. :					
Customer					
Component		Drg. Item No:		Qty	
Drg. No.		Rev. No.			
Specification					
QAP No. :		QAP Clause no.			
Material & Thickness		Lighting Intensity			
Surface Condition		Surface Temperature of job			
Test Technique		Date & Time of Examination			

	Material Brand & Batch Nos		
Penetrant		Penetration Time	
Cleaner			
Developer		Development Time	

Observations (Including recording and mapping of indications):

Conclusions (for acceptability/unacceptability):

Tested	Reviewed	Accepted
by :	**by :**	**by :**
Level :	**Level :**	**Level :**
Date :	**Date :**	**Date :**

Notes:

1. Material: Only NPCIL approved chemicals for liquid penetrant examination to be used and to be reported.
2. Only set of approved penetrant, cleaner & developer recommended by manufacture to be used. Intermixing of penetrant, cleaner & developer of different brand or different set of same brand is not permitted.

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

DOCUMENT NO: QAD/NDT-PROC/PT-02 REV- 2

TITLE	PROCEDURE FOR LIQUID PENETRANT EXAMINATION (COLOUR CONTRAST WATER WASHABLE TYPE)

This procedure can be used as reference procedure. A "Technique Sheet/Job specific procedure" is to be prepared identifying the NDT process variables and identifying "Acceptance criteria" (NPCIL Specification / Code clause) for a given application by the User/Vendor.

REVISION NO.	0	1	2
DATE OF ISSUE (Month/Year)	April 2007	August 2012	October 2017
TOTAL NO. OF PAGES (Including cover sheet)	8	8	15

REVISION CONTROL SHEET

PROCEDURE FOR LIQUID PENETRANT EXAMINATION (COLOUR CONTRAST WATER WASHABLE TYPE) DOCUMENT NO: QAD/NDT-PROC/PT-02 R2

Rev. No. & Date	Description of Revisions		
PP-E-2399 R 0 (April 2007)	Description of Revision: Original		
	Prepared by P.M. Shah	Reviewed by S.K. Agrawal	Approved by A.K. Shrivastava
PP-E-2399 R 1 (Aug. 2012)	Description of Revision: Editorial changes and changes as per latest codes/Standards		
	Revised by N.P.Upadhyay	Reviewed by Sundar Singh	Approved by K.P.Dwivedi
QAD/NDT-PROC/ PT-02 R2 (July 2017)	Description of Revision: Editorial changes and changes as per latest ASME codes (2015 edition). Refer sheet no. 3 for details.		
	16/10/17 V K Agarwal PT-Level – III ACE (QA)	16/10/17 J K Jain PT-Level – III AD(QA) Group-II	23.10.2017 L K Jain ED(QA)

Summery sheet of changes carried out in Revision-02

1. Cover page is modified.
2. Index page is introduced.
3. Title 'Purpose' is added.
4. Scope is modified. Annexure-1 is added for giving job details.
5. In clause no. 3.0, Applicable documents are added.
6. In clause no. 4.0, Procedure qualification is added.
7. Clause no.6.0 is added for calibration requirement of light meter.
8. Clause no.8.5, Warning is added for personal safety.
9. Clause no.10.0 is modified. It is added that acceptance criteria is only for reference. User should select according to job/code requirement.
10. Clause no.12.0 is modified; Methods of recording of indications added. It is added that report shall be signed by Level-II qualified personnel.
11. Clause no.11.0 is modified; Importance of post cleaning is highlighted.
12. Table no.1 is added containing Essential & nonessential variables.
13. Table no.3 is modified. Temperature range and dwell time is changed.
14. Annexure-1 is added giving details of job.
15. Annexure-2 (Format for Report) is modified for better clarity.

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   - 4.1 PERSONNEL QUALIFICATION
   - 4.2 PROCEDURE QUALIFICATION
5. EQUIPMENTS (PENETRANT MATERIALS)
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8. EXAMINATION
   - 8.1 SURFACE PREPARATION
   - 8.2 PRE CLEANING & DRYING
   - 8.3 APPLICATION OF PENETRANT
   - 8.4 REMOVAL OF EXCESS PENETRANT & CLEANING
   - 8.5 APPLICATION OF DEVELOPER
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ANNEXURES:

ANNEXURE-1: JOB DETAILS (PRODUCT FORM, MATERIAL, SHAPE, SIZE, EXTENT OF EXAMINATION & QUANTITY)
ANNEXURE-2: FORMAT FOR REPORT

1.0 PURPOSE:

1.1 This procedure describes the equipment and methods as well as the personnel qualifications essential for the performance of liquid penetrant examination of non-porous ferrous, non-ferrous and non-metallic materials such as fully densified ceramics, plastics, glass, etc using colour contrast water washable Dye penetrant test method.

2.0 SCOPE:

2.1 This procedure describes the requirements & acceptance criteria for liquid penetrant examination of non-porous ferrous, non-ferrous and non-metallic materials such as fully densified ceramics, plastics, glass, etc using colour contrast water washable Penetrant test method. Refer enclosed Annexure-1 for job details (product form, material, shape, size, extent of examination & quantity). Acceptance criteria will be in accordance with applicable PO/drawing/code/standard.

2.2 Typical surface discontinuities detectable by this method are cracks, seams, laps, cold shuts, porosity, laminations etc.

3.0 REFERENCE DOCUMENTS :

a. P.O. No…… (as applicable)

b. Drawing (as applicable)

c. ASME Section-V, Article-6 (Latest edition),

d. ASME Section-V, Article 24, SE-165(Latest edition)

e. ASME Sec VIII Div I/Div II (as applicable)

f. ASME Sec. III NB/NC/ND (as applicable)

4.0 PERSONNEL & PROCEDURE QUALIFICATION:

4.1 PERSONNEL QUALIFICATION :

Personnel performing non-destructive examination and evaluation shall be qualified in accordance with written procedure conforming to the recommended practice IS-13805/ISO-9712-3/SNT-TC-1A or any other recognized practice agreed with customer.

4.2 PROCEDURE QUALIFICATION :

Qualification of procedure using dwell times or condition different from those specified or for new materials shall be re-qualified. Refer table-1 for essential and non essential variables for guidance.

5.0 EQUIPMENTS (PENETRANT MATERIALS) :

- Cleaner.
- Penetrant.
- Developer.
- Automatic or semi automatic water spray equipment/ water immersion rinsing arrangement.
- Lint free cloth.
- Lighting equipment of minimum illumination of 1000 Lux.

5.1 For nickel base alloys and for stainless steel materials the penetrant materials such as cleaner, penetrant, developer, etc., used shall not contain sulphur or halogen above 25 PPM. Only NPC approved penetrant material shall be used for testing. Latest list of approved brand of NDT material should be obtained from QA Directorate, NPCIL, Mumbai.

5.2 Selection of liquid penetrant materials shall be from the same family (brand). Inter-mixing of family of liquid penetrant materials is not permitted.

6.0 CALIBRATION :

6.1 Adequate illumination is required to ensure no loss of the sensitivity in the examination. Examination shall be done under natural or suitable light. Illumination level shall be minimum 1000 LUX (100 fc) on the surface being tested. Light meter shall be calibrated at least once a year or whenever the meter has been repaired prior to use.

7.0 PRECAUTIONS :

The vapours from Cleaner, Penetrant and Developer may be hazardous. Proper ventilation should be provided & face mask should be used for breathing.

8.0 EXAMINATION :

8.1 SURFACE PREPARATION :

8.1.1 Surface preparation by grinding, machining or other suitable method may be employed where surface irregularities may mask indications.

8.1.2 The surface to be examined and all adjacent areas within at least 25 mm shall be dry and free from any dirt, lint, scale, rust, welding flux, weld spatter, grease, oil etc. These extraneous matters could obscure surface openings or otherwise interfere with examination.

8.1.3 The surface to be examined shall be cleaned with detergents, organic solvents, de-scaling solutions or paint removers. Degreasing and ultrasonic cleaning may be employed to increase cleaning efficiency. Cleaning method employed is an important part of the examination procedure. Cleaning solvents shall meet the requirement of Clause 5.1.

Table-2 may be used as guideline for selection of surface preparation method.

Caution: Blasting with shots or dull sand, buffing, wire brushing the soft material or machining with dull tools shall not be used as they may peen the discontinuities at the surface. When it is found necessary to use abrasive treatments, a chemical etching shall be followed to reopen surface discontinuities.

8.2 PRE CLEANING & DRYING :

Surface to be examined shall be cleaned thoroughly by solvent before application of penetrant. Drying shall be accomplished by normal evaporation or with forced hot air, as appropriate. A minimum period of time shall be established to ensure that the cleaning solution has evaporated prior to application of the penetrant.

8.3 APPLICATION OF PENETRANT :

8.3.1 The penetrant shall be applied by dipping, brushing or spraying. If the penetrant is applied by spraying using compressed air type apparatus, filters shall be placed at the air inlet to preclude contamination of the penetrant by oil, water, dirt or sediment that may have collected in the lines. Spraying should only be performed in a booth equipped with exhaust system.

8.3.2 The duration of penetrant time (dwell time) is critical and depends upon the material being inspected, the process through which it has passed and the type of discontinuities expected. The recommended (dwell) times are given in **Table 3.**

8.3.3 The temperature of the penetrant and the surface of the part to be examined shall not be below 5 deg C and not above 52 deg C throughout the examination period. Where it is not practical to comply with these temperature limitations, other temperatures and times shall be used provided the procedure is qualified.

8.4 REMOVAL OF EXCESS PENETRANT & CLEANING :

8.4.1 After the required penetrant dwell time, the excess penetrant on the surface being examined must be removed with water. It can be removed manually with a course spray or wiping the part surface with a dampened rag, automatic or semi-automatic water-spray equipment, or by water immersion. For immersion rinsing, parts are completely immersed in the water bath with air or mechanical agitation.

8.4.2 The temperature of water shall be maintained within the range of 10 deg C to 38 deg C. The spray rinse water pressure shall not exceed 40psi (275kPa). When hydro-air pressure spray guns are used, the air pressure should not exceed 25 psi (172kPa). The

total rinsing time shall not exceed 120 seconds unless otherwise specified by material specification.

Caution: Overwashing should be avoided. Excessive washing can cause penetrant to be washed out of discontinuities.

8.4.3 Surface shall be dried before the application of developer. For this method, the surface shall be dried by blotting with clean materials or by using circulating warm air, provided the temperature of the surface is not raised above 52 deg C. If the surface remains in dried condition for more than 30 minutes, it may impair the sensitivity of the examination.

8.5 APPLICATION OF DEVELOPER :

8.5.1 The developer shall be applied as soon as possible after the removal of the excess penetrant and after drying as required. With colour contrast penetrant, only wet developer shall be used.

8.5.2 Prior to applying suspension type wet developer to the surface, the developer must be thoroughly agitated to ensure adequate dispersion of suspended particles.

(a) Aqueous Developer Application:

Aqueous developer may be applied to either a wet or dry surface. It shall be applied by dipping, spraying or other means provided a thin coating is obtained over the entire surface being examined.

(b) Non-aqueous Developer Application:

Non-aqueous developer shall be applied (after drying of surface being tested) by spraying, except where safety or restricted access precludes it. Under such conditions developer may be applied by brushing. Drying shall be by normal evaporation.

Warning: The vapour from evaporation, volatile solvent developer carrier may be hazardous. Proper ventilation should be provided & face mask should be used for breathing.

8.6 Post Cleaning :

Post cleaning shall be carried out immediately after the evaluation & interpretation of test results.

9.0 EVALUATION:

9.1 Observe the surface during the application of the developer to detect nature of any indications which tend to bleed out profusely. Final examination shall be done between 10 minutes at the earliest and 30 minutes at the latest after application of the

developer. The nature of discontinuities corresponding to the indications shall be defined depending upon the method of setting, appearance, direction, shape and dimensions of the same. If the bleed out does not alter the examination results, longer periods are permitted. If the surface to be examined is large enough to preclude complete examination within the prescribed time, the surface shall be examined in increments.

9.2 With colour contrast penetrant, the developer forms a reasonably uniform coating. Surface discontinuities are indicated by bleeding out of the penetrant which is normally of a deep red colour. Indication with a light pink colour may indicate excessive cleaning. Inadequate cleaning may leave an excessive background making interpretation difficult.

9.3 As the developer dries to a smooth, even white coating, indications will appear at the locations of discontinuities. Depth of surface discontinuities may be correlated with the richness of colour and speed of bleeding out. However, localized surface imperfections such as from machining marks or surface conditions may produce similar indications which are non-relevant.

9.4 Usually, a crack or similar opening will show a line and light cracks or partially welded lap will show a broken line. Gross porosity may produce large indications covering an entire area. Very fine porosity is indicated by random dots.

9.5 Any non-relevant indication shall be regarded as a defect until the indication is either eliminated by surface conditioning or it is proved non-relevant by other NDT methods.

9.6 Linear indications are those indications in which the length is more than three times the width. Rounded indications are indications which are circular or elliptical with the length equal to or less than three times the width.

9.7 All indications shall be evaluated in terms of the acceptance standards of the referencing documents.

10.0 ACCEPTANCE CRITERIA (for reference & guidance only):

Acceptance criteria of the indications are as per the acceptance norms as specified in PO specification/Technical Specification/Drawing/ Data Sheet etc, as applicable. Following acceptance standards are given for reference (for welds). Applicable standards shall be followed for casting, Forging and wrought materials etc.

10.1 ASME Sec. VIII Div.I/II (Edition 2015)

a) Only imperfections producing indications with major dimensions greater than 1/16 in (1.5mm) shall be considered to be relevant imperfections.

b) All surfaces to be examined shall be free of relevant linear indications.

c) Relevant rounded indication greater than 3/16 in (5 mm) shall not be acceptable.

d) Four or more relevant rounded indications in a line separated by 1/16 in (1.5mm) or less (edge to edge), shall not be acceptable.

e) Crack like indications detected, irrespective of surface conditions, are unacceptable

10.2 ASME Sec-III-NB/NC/ND (Edition 2015)

a) Only imperfections producing indications with major dimensions greater than 1/16 in (1.5mm) shall be considered to be relevant imperfections.

b) Imperfections producing the following indications are unacceptable:

1) Any cracks or linear indications;

2) Rounded indications with dimensions greater than 3/16 in. (5 mm);

3) Four or more rounded indications in a line separated by 1/16 in (1.5mm) or less edge to edge;

4) Ten or more rounded indications in any 6 sq in of surface with the major dimension of this area not to exceed 6 in. (150mm) with the area taken in the most unfavourable location relative to the indications being evaluated.

11.0 POST EXAMINATION ACTIVITIES :

Surfaces examined shall be cleaned thoroughly after evaluation of the test with dry cotton cloth with or without solvent. This is more important in austenitic SS, titanium, nickel based or high temperature alloys. Impurities present in penetrant materials such as sulphur, halogens and alkali may cause embrittlement or corrosion.

12.0 RECORD OF EXAMINATION (FORMAT OF REPORT):

Record for each examination shall be prepared in a format, attached with this procedure as Annexure-2. The type of indications (linear or rounded), location and extent (length or diameter or aligned) shall be recorded. Cello tapes, sketches or photographs can be used for recording the indications.

Report shall be signed by at least level-II qualified personnel.

13.0 OPERATING EXPERIENCE :

13.1 It is observed that most qualified personals are unaware about importance of pre cleaning of the surface before conducting PT examination and clean the surface by means of shot blasting, buffing, wire brushing the soft material or machining the

surface with dull tools. These shall not be used as they may peen the discontinuities at the surface. When it is found necessary to use abrasive treatments, a chemical etching shall be followed to reopen surface discontinuities.

13.2 It is noted that some of private companies employ only one qualified personal. Generally job is performed by unqualified personals, who do not understand the procedure requirements. The sensitivity of PT examination is greatly influenced by followings:

- Inadequate pre cleaning of surface.
- Under cleaning or over cleaning of surface after completion of dwell time.
- Cleaning the surface in time less than specified dwell period or in time much more than specified dwell period.
- Evaluating the test results before completion of specified development time.

In view of this, it is recommended that PT examination should always be performed by at least level-I qualified personal only.

13.3 Persons performing PT examination do not take adequate personnel protection. Penetrant used for testing contains different types of chemicals which may be hazardous for skin and lungs, if inhaled. Therefore hand gloves should be used, proper ventilation should be maintained & mask should be used for breathing.

13.4 Generally personals in industries do not understand the value of post cleaning and do not perform this activity after completion of PT examination. If the dye and developer is left on the material for long time, the chemicals present in the penetrants may affect the characteristic of material and in turn its service life. Therefore post cleaning is extremely important and must be performed immediately after completion of PT examination.

TABLE -1

REQUIREMENTS OF LIQUID PENETRANT EXAMINATION PROCEDURE

Sl No.	Requirement	Essential Variable	Nonessential Variable
1.	Identification of and any change in type or family group of penetrant materials including developers etc.	X	-----
2.	Surface preparation (finishing and cleaning, including type of cleaning solvent).	X	-----
3.	Method of applying penetrant.	X	-----
4.	Method of removing excess surface penetrant.	X	-----
5.	Hydrophilic or lipophilic emulsifier concentration and dwell time in dip tanks and agitation time for hydrophilic emulsifiers.	X	-----
6.	Hydrophilic emulsifier concentration in spray applications.	X	-----
7.	Method of applying developer.	X	-----
8.	Minimum and maximum time periods between steps and drying aids.	X	-----
9.	Decrease in penetrant dwell time.	X	-----
10.	Increase in developer dwell time. (Interpretation Time)	X	-----
11.	Minimum light intensity.	X	-----
12.	Surface temperature outside 40°F to 125°F (5°C to 52°C) or as previously qualified.	X	-----
13.	Performance demonstration, when required.	X	-----
14.	Personnel qualification requirements.	-----	X
15.	Materials, shapes, or sizes to be examined and the extent of examination.	-----	X
16.	Post-examination cleaning technique.	-----	X

X means- applicable

TABLE -2

APPLICABLE METHODS FOR SURFACE PREPARATION

Product	Surface preparation
Weld	Wire brushing, Grinding, Solvent cleaner
Machined Component	Solvent cleaner, Degreasing, Ultrasonic cleaning
Fittings/ Forgings	Grindings, Machining, Solvent cleaning, Degreasing
Castings	Grinding, Sand blasting, Shot blasting
Non- ferrous Material	Machining, Grinding, Solvent cleaning
Non metal	Solvent cleaning, Degreasing, Detergent cleaning

TABLE -3

RECOMMENDED MINIMUM DWELL TIMES

Material	Material Form	Type of Discontinuity	Dwell Times # (Minutes)	
			Penetrant	Developer
Aluminium, magnesium, Steel, brass and bronze, titanium and high temperature alloys	Castings and welds	Cold shuts, porosity, lack of fusion, cracks (All forms)	5	10
	Wrought materials – extrusions, forgings, plate	Laps, Cracks (all forms)	10	20
Carbide-tipped tools	Brazed or welded	Lack of fusion, Porosity, cracks	5	10
Plastic	All forms	Cracks	5	10
Glass	All forms	Cracks	5	10
Ceramic	All forms	Cracks, porosity	5	10

Dwell time given is for temperature range from 10°C to 52°C. For temperature range between 5°C to 10°C, recommended minimum dwell time is 20 minutes.

Development time begins as soon as wet developer coating has dried on surface of parts (Recommended minimum).

Annexure-1

Job Details (Product form, material, Shape, Size, extent of examination & Quantity)

Annexure-2

FORMAT FOR REPORT

Manufacturer Name & Address

Report for Dye Penetrant Examination

Report No. :
Date :

Procedure No & Rev:					
Manufacture Ref. No.: (Package contractor/main vendor/sub-vendor/supplier)					
P.O. No / Sub order No. :					
Customer					
Component		Drg. Item No:		Qty	
Drg. No.		Rev. No.			
Specification					
QAP No. :		QAP Clause no.			
Material & Thickness		Lighting Intensity			
Surface Condition		Surface Temperature of job			
Test Technique		Date & Time of Examination			

	Material Brand & Batch Nos		
Penetrant		Penetration Time	
Cleaner			
Developer		Development Time	

Observations (Including recording and mapping of indications):

Conclusions (for acceptability/unacceptability):

Tested	Reviewed	Accepted
by :	**by :**	**by :**
Level :	**Level :**	**Level :**
Date :	**Date :**	**Date :**

Notes:

1. Material: Only NPCIL approved chemicals for liquid penetrant examination to be used and to be reported.
2. Only set of approved penetrant, cleaner & developer recommended by manufacture to be used. Intermixing of penetrant, cleaner & developer of different brand or different set of same brand is not permitted.

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)

DIRECTORATE OF QUALITY ASSURANCE

PROCEDURE NO.: QAD/NDT-PROC/PT-03- REV. 02

TITLE :	PROCEDURE FOR LIQUID PENETRANT EXAMINATION (FLUORESCENT)

This Procedure can be used as reference procedure. A "Technique Sheet/Job specific procedure" is to be prepared identifying the NDT process variables and identifying "Acceptance criteria" (NPCIL Specification / Code clause) for a given application by the user/Vendor.

REVISION NO.	00	01	02	
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ORIGINAL

	NAME	SIGNATURE	DATE
PREPARED BY	P. M. Shah	Sd/-	7-4-2007
REVIEWED BY	S.K. Agrawal	Sd/-	7-4-2007
APPROVED BY	A. K. Shrivastava	Sd/-	7-4-2007

(For revision status refer revision control sheet)

REVISION CONTROL SHEET

PROCEDURE NO. : QAD/NDT-PROC/PT-03- REV. 02

PROCEDURE FOR LIQUID PENETRANT EXAMINATION (FLUORESCENT)

Rev. No.	Description of revision	Revised/ Prepared by	Reviewed by	Approved by
1 (Aug 2012)	Editorial changes and changes as per latest codes/standards	30/8/2012 N.P.Upadhyay PT-Level-III	30.8.12 Sundar Singh PT-Level-III	30.8.2012 K.P.Dwivedi ED(QA)
2 (Oct 2017)	Editorial changes and changes as per latest codes/standards	Manjunatha Rao PT-Level-III	25/10/2017 A.Somasundaram PT-Level-III	26.10.2017 L.K.Jain, ED(QA)

1.0 PURPOSE:

This Procedure describes the equipment and methods as well as the personnel qualifications essential for the performance of the Liquid Penetrant Examination (Fluorescent) of Nuclear Steam generator Components and other inspection.

This is in accordance with the requirements of ASME Section-V, Article-6.

2.0 SCOPE :

2.1 This documents details the procedure for liquid penetrant examination of non-porous ferrous, non-ferrous and non-metallic materials such as ceramics, plastics, Glass, etc using Florescent Dye Penetrant Test Method.

2.2 Typical surface discontinuities detectable by this method are cracks, seams, laps, cold shuts, porosity, laminations, etc.(This method is generally applied to detect fine defects on machined surface)

3.0 REFERENCE DOCUMENTS :

a) ASME Section-V, Article-6,

b) ASME Section-V, Article 24, SE-165-02

c) ASME Sect VIII Div I/Div II (as applicable)

d) ASME Sect. III NB/NC/ND (as applicable)

4.0 PERSONNEL QUALIFICATION :

Personnel performing non-destructive examination and evaluation shall be qualified to the recommended practice IS-13805/ISO-9712-3/SNT-TC-1A or any other recognized practice.

5.0 EQUIPMENT.

NPCIL Approved Penetrant (Fluorescent), Cleaner, Developer (Dry/Wet), Non-aqueous Power source, lint free cloth, Tissue papper, Black Light
(Shall have a wave length of 320 to 380nm) and black light meter.

25/10/2017

6.0 CALIBRATION :

Light meters, both visible and fluorescent (black) light meters, shall be calibrated at least once a year or whenever the meter has been repaired. If meters have not been in use for one year or more, calibration shall be done before being used.

7.0 PRECAUTIONS :

With spray applications, it is important that there be proper ventilation. This is generally accomplished through the use of a properly designed spray booth and exhaust system.

8.0 EXAMINATION :

8.1 DESCRIPTION OF TEST

In principle, liquid penetrant is applied to the surface to be examined and allowed to enter in-to the discontinuities. Excess penetrant removed, the part is dried and a developer is applied. The developer functions both as a blotter to absorb penetrant that has been trapped in discontinuities and as a contrasting back-ground to enhance the visibility of penetrant indications.

8.1.1 For nickel base alloys and/or for stainless steel materials the penetrant materials, cleaner, penetrant, developer, etc., used shall not contain sulphur or halogen. (Sulphur content shall not exceed 0.1% by weight, the total chlorine and fluorine content shall not exceed 0.1% by weight).

8.2 Only NPCIL approved penetrant materials to be used for testing.

8.3 Selection of liquid penetrant material shall be from the same family (brand). Inter-mixing of family of liquid penetrant materials is not permitted. If to be used a detailed procedure shall be demonstrated.

8.4 Surface preparation :

8.4.1 Surface preparation by grinding or machining or other method may be employed where surface irregularities may mask indications of unacceptable discontinuities.

8.4.2 The surface to be examined and all adjacent areas within at least 25 mm shall be dry and free from any dirt, lint, scale, rust, welding flux, weld spatter, grease, oil and paint etc. These extraneous matters could obscure surface openings or otherwise interfere with examination.

8.4.3 The surface to be examined shall be cleaned with detergents, organic solvents, descaling solutions or paint removers. Degreasing and ultrasonic cleaning may be employed to increase cleaning efficiency. Cleaning method employed is an important part of the examination procedure. Cleaning solvents shall meet the requirement of clause 8.1.1.

8.5 Procedure Requirements:

Liquid penetrant examination shall be performed in accordance with a written procedure which shall as a minimum, contain the requirements listed in Table.T.P.1. The written procedure shall establish a single value, or range of values, for each requirement.

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8.5.1 Procedure Qualification:

When procedure qualification is specified by the referencing code section, a change of a requirement in Table.T.P.1. Identified as an essential variable shall require requalification of the written procedure by demonstration. A change of a requirement identified as a nonessential variable does not require requalification of the written procedure. All changes of essential or nonessential variables from those specified within the written procedure shall require revision of, or an addendum to, the written procedure.

8.5.2 Minimum and Maximum step Time.

The written procedure shall have minimum and maximum times for the applicable examination steps listed in Table.T.P.2.

Table T.P.1
Requirements for an Liquid Penetrant Examination Procedure

Requirements	Essential Variable	Nonessential Variable
Identification of and any change in type or family group of penetrant materials including developers, emulsifiers, etc.	X	...
Surface preparation (finishing and cleaning, including type of cleaning solvent) Method of removing Penetrant	X	...
Method of removing excess surface penetrant	X	...
Method of applying developer	X	...
Minimum and maximum time periods between steps and drying aids	X	...
Decrease in penetrant dwell time	X	...
Increase in developer dwell time (Interpretation Time)	X	...
Minimum light intensity	X	...
Surface temperature outside 40°F to125°F(5°C to 52°C) or as previously qualified	X	...
Performance demonstration, when required	X	...
Personnel qualification requirements	...	X
Materials, shapes, or size to be examined and the extent of examination	...	X
Post-examination cleaning technique	...	X

Table-1: may be used as guideline for selection of surface preparation method.

Caution: Blasting with shot or dull sand, rotofinishing, buffing, wire brushing the soft material or machining with dull tools shall not be used as they may peen the discontinuities at the surface.

Note: Requalification of the procedure to be used may be required when a change is made to the procedure or when penetrant material substitution is made.

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Table-T.P.2

Minimum and Maximum Time Limits for Steps in Penetrant Examination Procedures

Procedure Step	Minimum	Maximum
Drying after preparation	X	...
Penetrant dwell	X	X
Penetrant removal water washable/solvent removable	...	...
Prerinse	...	X
Immersion	...	X
Water-emulsifier spray	...	X
Water immersion or spray post-rinse	...	X
Drying after penetrant removal		
Solvent removal penetrants	...	X
Water-washable and post-emulsifiable penetrants	...	X
Developer application	...	X
Developing and interpretation time	X	X

8.6 Drying :

After cleaning, Drying the surface to be examined, shall be accomplished by normal evaporation or with forced hot air, as appropriate. A minimum period of time shall be established to ensure that the cleaning solution has evaporated prior to application of the penetrant.

8.7 Application of Penetrants :

8.7.1 The penetrant shall be applied by dipping, brushing or spraying. If the penetrant is applied by spraying using compressed air type apparatus, filters shall be placed at the air inlet to preclude contamination of penetrant by oil, water or dirt sediment that may have collected in the lines. Spraying should only be performed in a booth equipped with exhaust system.

8.7.2 The length of penetration time (Dwell time) is critical and depends upon the material being inspected, the process through which it has passed and the type of discontinuities expected. The recommended penetration time is given in Table 2.

8.7.3 The temperature of the penetrant and the surface of the part to be examined shall not be below 04 deg C and not above 52 deg C throughout the examination period. Where it is not practical to comply with these temperature limitations, other temperatures and times shall be used provided the procedures is qualified. The maximum dwell time shall not exceed 2 hr or as qualified by demonstration for specific application. Regardless of the length of the dwell time, the penetrant shall not be allowed to dry. If for any reason the penetrant does dry, the examination procedure shall be repeated, beginning with a cleaning of the examination surface.

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8.8 Removal of Excess Penetrant :

After the penetration time specified in the procedure has elapsed, any penetrant remaining on the surface shall be removed, taking care to minimize removal of penetrant from discontinuities

8.8.1 Solvent removable penetrants :

Excess penetrant shall be removed by wiping with a clean, dry, lint free cloth or absorbent paper. Repeating the operation until most traces of penetrants have been removed. The remaining traces shall be removed by wiping the surface lightly with cloth or absorbent paper, lightly moisturized with solvent.

8.8.2 Removal of penetrant shall be confirmed in black light.

Caution: Care shall be taken to avoid excess solvent as this may remove penetrants from discontinuities. Flushing the surface with solvent following the application of the penetrant and prior to developing is prohibited.

8.9 Drying :

Drying of surface of the parts is necessary prior to applying dry or noaqueous developers or following the application of aqueous developers.

a) If post emulsifying or water washable method is used, the surface shall be dried by blotting with clean materials or by using circulating warm air, provided the temperature of the surface is not raised above 52 deg C.

b) For solvent removable method, the surface may be dried by normal evaporation, blotting, wiping or forced air.

8.9.1 Application of Developer :

The developer shall be applied as soon as possible after the removal of the excess penetrant. Any of two types of developer, dry or wet, shall be used with fluorescent penetrant.

8.9.2 Application of Dry Developer :

Dry developer shall be applied by a soft brush, a hand operated powder bulb or a powder gun or other means provided the powder is dusted evenly over the entire surface being examined.

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8.9.3 Application of wet Developer

Prior to applying suspension type wet developer to the surface, the developer must be thoroughly agitated to ensure adequate dispersion of suspended particles.

a) Aqueous Developer Application:

Aqueous developer may be applied to either a wet or dry surface. It shall be applied by dipping, spraying or other means provided a thin coating is obtained over the entire surface being examined. Drying time may be decreased by using warm air, provided the surface temperature of the part is not raised above 52 deg C. Blotting is not permitted.

b) Non-aqueous Developer Application:

Non-aqueous developer shall be applied by spraying, except where safety or restricted access preclude it. Under such conditions developer may be applied by brushing. Drying shall be by normal evaporation.

8.10 Examination of the surface shall be carried out with a high intensity black light in a darkened area or booth. Black light shall have a wave length of 320 to 380 nm. The bulbs shall be allowed to warm up for not less than 10 minutes prior to use in the examination. The black light intensity shall be minimum 1000 uW/cm2 at a distance of 15 inch (38.1cm) on the surface of the part being examined. The operator should allow his eyes to become accustom to the darkness of the inspection booth for at least 5 minutes before inspecting the parts. He should avoid looking direct into the black light and also avoid going from the darkness to the light and back again without allowing sufficient time for his eyes to adjust to the darkness.

The intensity shall be measured with a black light meter prior to use, when ever the light power source is interrupted or changed and at the completion of the examination or series or examinations. Reflectors and fillers should be checked daily for cleanliness and integrity and, if necessary cleaned prior to use. Cracked or broken filters shall be replaced immediately. Since a drop in line voltage can cause decreased black light output with consequent inconsistent performance, a constant-voltage transformer should be used when there is evidence of voltage fluctuation.

8.11 Observe the surface during the application of the developer to detect nature of any indications which tend to bleed out profusely. Final examination shall be done between 10 minutes at the earliest and 30 minutes at the latest after application of the developer. The nature of discontinuities corresponding to the indications shall be defined depending upon the method of setting, appearance, direction, shape and dimensions of the same. If the bleed out does not alter the examination results, longer periods are permitted. If the surface to be examined is large enough to preclude complete examination within the prescribed time the surface shall be examined in increments.

9.0 Evaluation.

9.1 Analysis:

As the developer dries to a smooth, even white coating, indications will appear at the locations of discontinuities. Depth of surface discontinuities may be correlated with the richness of colour and speed of bleeding out. However, localized surface imperfections such as from machining marks or surface conditions may produce similar indications which are non-relevant.

9.2 Usually, a crack or similar opening will show a line and light cracks or partially welded lap will show a broken line. Gross porosity may produce large indications covering an entire area. Very fine porosity is indicated by random dots.

9.3 Any non-relevant indication shall be regarded as a defect until the indication is either eliminated by surface conditioning or it is proved non-relevant by other NDT methods.

9.4 Linear indications are those indications in which the length is more than three times the width. Rounded indications are indications which are circular or elliptical with the length less than three times the width.

9.5 All indications shall be evaluated in terms of the acceptance standards of the referencing documents.

10.0 ACCEPTANCE CRITERIA:

Acceptance Standard of the indications is as per the acceptance norms as specified in PO specification/Technical specification/Drawing, etc, as applicable. Following acceptance standards are given for reference (for welds).

10.1 ASME Sect. VIII Div.1

These acceptance standards shall apply unless other more restrictive standards are specified for specific materials or applications within this Division.

All surfaces to be examined shall be free of:

(a) Relevant linear indications;

(b) Relevant rounded indications greater than 3/16 in. (5 mm);

(c) Four or more relevant rounded indications in a line Separated by 1/16 in. (1.5 mm) or less (edge to edge).

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10.2 ASME Sect-III-NB/NC/ND

a) Only imperfections producing indications with major dimensions greater than 1/16 in. (1.5 mm) are required to be evaluated for acceptance.

b) Imperfections producing the following indications are unacceptable:

1) linear indications with dimensions greater than 1/16 in. (1.5 mm);

2) rounded indications with dimensions greater than 3/16 in. (5 mm);

3) four or more rounded indications in a line separated by 1/16 in. (1.5 mm) or less edge to edge;

4) ten or more rounded indications in any 6 square in. (4 000 mm2) of surface with the major dimension of this area not to exceed 6 in. (150 mm) with the area taken in the most unfavourable location relative to the indications being evaluated.

11.0 POST EXAMINATION ACTIVITIES :

Surfaces examined shall be cleaned after evaluation of the test with dry cotton cloth with or without water rinse. When post-examination cleaning is required by the procedure, it should be conducted as soon as practical after Evaluation and Documentation using a process that does not adversely affect the part.

12.0 RECORDS :

Record for each examination shall be prepared in a format, attached with this procedure.

13.0 OPERATING EXPERIENCE:

Not Applicable.

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Table -1

Applicable method for surface preparation

Surface	Surface preparation
Weld	**Wire brushing, Grinding, Solvent cleaner**
Machined Component	**Solvent cleaner, Degreasing, Ultrasonic cleaning**
Fittings/ Forgings	**Grindings, Machining, Solvent cleaning, Degreasing**
Non- ferrous Material	**Machining, Grinding, Solvent cleaning**
Non metal	**Solvent cleaning, Degreasing, Detergent cleaning**

Table -2

Suggested Penetration and developer dwelling time for fluorescent solvent removable test method

Material	Material Form	Type of Discontinuity	Dwell Times (Minutes)	
			Penetrant	Developer
Aluminum, magnesium, Steel, brass and bronze, titanium and high temperature alloys	Castings and welds	Cold shuts, porosity, lack of fusion, cracks (All forms)	5	10
	Wrought materials – extrusions, forgings, plate	Laps, Cracks (all forms)	10	10
Carbide-tipped tools	Brazed or welded	Lack of fusion, Porosity, cracks	5	10
Plastic	All forms	Cracks	5	10
Glass	All forms	Cracks	5	10
Ceramic	All forms	Cracks, porosity	5	10

Development time for final interpretation begins immediately after the application of dry developer or as soon as wet developer coating has dried on surface of parts (Recommended minimum).

Note: For temp range from 10ºC to 52ºC.
For temp from 5ºC temp to 10ºC Minimum penetrate dwell time shall be 2 times the value listed.
Unless otherwise specified, the Dwell time shall not exceed the maximum recommended by the manufacturer.
Developing time begins immediately after the application of dry powder developer or as soon as the wet (aqueous or non-aqueous) developer coating is dry (that is, the water or solvent carrier has evaporated to dryness). The maximum permitted developing times shall be four hours for dry powder developer, two hours for aqueous developer and one hour for non-aqueous developer.

25/10/2017

FORMAT FOR REPORT

Manufacturer Name & Address

Report for Dye Penetrant Examination

Report No. :
Date :

Procedure No & Rev:					
Manufacture Ref. No.:					
P.O. No / Sub order No. :					
Customer					
Component		Drg. Item No:		Qty	
Drg. No.		Rev. No.			
Specification					
QAP No. :		QAP Clause.			
Material & Thickness		Lighting Equipment			
Surface Condition		Surface Temperature of job			
Test Method		Date & Time of Examination			

	Material Brand & Batch Nos		
Dye penetrant		Penetration Time	
Cleaner			
Developer		Development Time	

Observations (Including recording and mapping of indications):

Conclusions (for acceptability/unacceptability):

Tested	Reviewed	Accepted
by :	**by :**	**by :**
Level :	**Level :**	**Level :**
Date :	**Date :**	**Date :**

Notes:

1. Material: Only approved material for dye penetrant testing to be used and to be reported.

25/10/2017

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

PROCEDURE NO.: QAD/NDT-PROC/PT-04 REV. 02

TITLE :	PROCEDURE FOR LIQUID PENETRANT EXAMINATION (GENERAL REQUIREMENT)

This Procedure can be used as reference procedure. A "Technique Sheet/Job specific procedure" is to be prepared identifying the NDT process variables and identifying "Acceptance criteria" (NPCIL Specification / Code clause) for a given application by the user/Vendor.

REVISION NO.	0	1	02	
DATE OF ISSUE (Month/Year)	APRIL 2007	August 2012	October 2017	
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ORIGINAL

	NAME	SIGNATURE	DATE
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(For revision status refer revision control sheet)

REVISION CONTROL SHEET

PROCEDURE NO. : QAD/NDT-PROC/PT-04 REV. 02

PROCEDURE FOR LIQUID PENETRANT EXAMINATION (GENERAL REQUIREMENT)

Rev. No.	Description of revision	Revised/ Prepared by	Reviewed by	Approved by
1 (Aug 2012)	Editorial changes and changes as per latest codes/standards	30/8/2012 N.P.Upadhyay PT-Level-III	30.8.12 Sundar Singh PT-Level-III	30.8.2012 K.P.Dwivedi ED(QA)
2 (Oct 2017)	Editorial changes and changes as per latest codes/standards	Manjunatha Rao PT-Level-III	25/10/2017 A.Somasundaram PT-Level-III	26.10.2017 L.K.Jain, ED(QA)

1.0 PURPOSE:

This Procedure describes the equipment and methods as well as personnel qualifications essential for the performance of the Liquid penetrant examinations visible and fluorescent of nuclear components and other inspections.

This is in accordance with the requirements of ASME Sec V , Article-6.

2.0 SCOPE :

2.1.1 This documents details the procedure for liquid penetrant examination of non-porous ferrous, non-ferrous and non-metallic materials such as ceramics, plastics, Glass, etc using Florescent, Visible Dye Penetrant Test Method.

2.1.2 Typical surface discontinuities detectable by this method are cracks, seams, laps, cold shuts, porosity, laminations, etc.(Florescent method is generally applied to detect fine defects on machined surface)

3.0 REFERENCE DOCUMENTS :

a) ASME Section-V, Article-6,

b) ASME Section-V, Article 24, SE-165-02

c) ASME Sect VIII Div I/Div II (as applicable)

d) ASME Sect. III NB/NC/ND (as applicable)

4.0 PERSONNEL QUALIFICATION :

Personnel performing non-destructive examination and evaluation shall be qualified to the recommended practice IS-13805/ISO-9712-3/SNT-TC-1A or any other recognized practice.

5.0 EQUIPMENT.

NPCIL Approved Penetrant (Variable and Fluorescent), Cleaner, Developer (Dry/Wet), Non-aqueous

Power source, lint free cloth, Tissue papper, Black Light

(Shall have a wave length of 320 to 380nm) and black light meter and light meter.

6.0 CALIBRATION :

Light meters, both visible and fluorescent (black) light meters, shall be calibrated at least once a year or whenever the meter has been repaired. If meters have not been in use for one year or more, calibration shall be done before being used.

7.0 PRECAUTIONS :

With spray applications, it is important that there be proper ventilation. This is generally accomplished through the use of a properly designed spray booth and exhaust system.

8.0 EXAMINATION :

8.1 DESCRIPTION OF TEST

In principle, liquid penetrant is applied to the surface to be examined and allowed to enter in-to the discontinuities. Excess penetrant removed, the part is dried and a developer is applied. The developer functions both as a blotter to absorb penetrant that has been trapped in discontinuities and as a contrasting back-ground to enhance the visibility of penetrant indications.

8.1.1 Either a colour contrast or fluorescent penetrant method may be used. Appropriate test method may be selected from Table-1. Any one of the following penetrants shall be used.

a) Solvent removable
b) Post Emulsifying
c) Water washable

8.1.2 For nickel base alloys and/or for stainless steel materials the penetrant materials, cleaner, penetrant, developer, etc., used shall not contain sulphur or halogen. (Sulphur content shall not exceed 0.1% by weight, the total chlorine and fluorine content shall not exceed 0.1% by weight).

8.2 Only NPCIL approved penetrant materials to be used for testing. Latest list of approved brand of NDT material to be obtained from QA Directorate, NPCIL.

8.3 Selection of liquid penetrant material shall be from the same family (brand). Inter-mixing of family of liquid penetrant materials is not permitted. If to be used a detailed procedure shall be demonstrated.

8.4 Surface preparation :

8.4.1 Surface preparation by grinding or machining or other method may be employed where surface irregularities may mask indications of unacceptable discontinuities.

8.4.2 The surface to be examined and all adjacent areas within at least 25 mm shall be dry and free from any dirt, lint, scale, rust, welding flux, weld spatter, grease, oil and paint etc. These extraneous matters could obscure surface openings or otherwise interfere with examination.

8.4.3 The surface to be examined shall be cleaned with detergents, organic solvents, descaling solutions or paint removers. Degreasing and ultrasonic cleaning may be employed to increase cleaning efficiency. Cleaning method employed is an important part of the examination procedure. Cleaning solvents shall meet the requirement of clause 8.1.2.

Table-1 and 1A may be used as guideline for selection of surface preparation method.

Caution: Blasting with shots or dull sand, roto finishing, buffing, wire brushing the soft material or machining with dull tools shall not be used as they may peen the discontinuities at the surface.

8.5 Procedure Requirements:

Liquid penetrant examination shall be performed in accordance with a written procedure which shall as a minimum, contain the requirements listed in Table.T.P.1. The written procedure shall establish a single value, or range of values, for each requirement.

8.6 Procedure Qualification:

When procedure qualification is specified by the referencing code section, a change of a requirement in Table.T.P.1. Identified as an essential variable shall require requalification of the written procedure by demonstration. A change of a requirement identified as a nonessential variable does not require requalification of the written procedure. All changes of essential or nonessential variables from those specified within the written procedure shall require revision of, or an addendum to, the written procedure.

8.7 Minimum and Maximum step Time.

The written procedure shall have minimum and maximum times for the applicable examination steps listed in Table.T.P.2.

25/10/2017

Table T.P.1
Requirements for an Liquid Penetrant Examination Procedure

Requirements	Essential Variable	Nonessential Variable
Identification of and any change in type or family group of penetrant materials including developers, emulsifiers, etc.	X	...
Surface preparation (finishing and cleaning, including type of cleaning solvent)	X	...
Method of applying penetrant	X	...
Method of removing excess surface penetrant	X	...
Method of applying developer	X	...
Hydrophilic or lipophilic emulsifier concentration and dwell time in dip tanks and agitation time for hydrophilic emulsifiers	X	...
Hydrophilic emulsifier concentration in spray applications Method of applying developer	X	...
Minimum and maximum time periods between steps and drying aids	X	...
Decrease in penetrant dwell time	X	...
Increase in developer dwell time (Interpretation Time)	X	...
Minimum light intensity	X	...
Surface temperature outside 40°F to125°F(5°C to 52°C) or as previously qualified	X	...
Performance demonstration, when required	X	...
Personnel qualification requirements	...	X
Materials, shapes, or size to be examined and the extent of examination	...	X
Post-examination cleaning technique	...	X

Table-1: may be used as guideline for selection of surface preparation method.

Caution: Blasting with shot or dull sand, rotofinishing, buffing, wire brushing the soft material or machining with dull tools shall not be used as they may peen the discontinuities at the surface.

Note: Requalification of the procedure to be used may be required when a change is made to the procedure or when penetrant material substitution is made.

Table-T.P.2

Minimum and Maximum Time Limits for Steps in Penetrant Examination Procedures

Procedure Step	Minimum	Maximum
Drying after preparation	X	…
Penetrant dwell	X	X
Penetrant removal water washable/solvent removable	…	…
Penetrant removal with Lipophilic emulsifier.	X	X
Penetrant removal with Hydrophilic emulsifier.		
Prerinse	…	X
Immersion	…	X
Water-emulsifier spray	…	X
Water immersion or spray post-rinse	…	X
Drying after penetrant removal		
Solvent removal penetrants	…	X
Water-washable and post-emulsifiable penetrants	…	X
Developer application	…	X
Developing and interpretation time	X	X

8.8 Drying :

After cleaning, Drying the surface to be examined, shall be accomplished by normal evaporation or with forced hot air, as appropriate. A minimum period of time shall be established to ensure that the cleaning solution has evaporated prior to application of the penetrant.

8.9 Application of Penetrants :

8.9.1 The penetrant shall be applied by dipping, brushing or spraying. If the penetrant is applied by spraying using compressed air type apparatus, filters shall be placed at the air inlet to preclude contamination of penetrant by oil, water or dirt sediment that may have collected in the lines. Spraying should only be performed in a booth equipped with exhaust system.

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8.9.2 The length of penetration time (Dwell time) is critical and depends upon the material being inspected, the process through which it has passed and the type of discontinuities expected. The recommended penetration time is given in Table 2.

8.9.3 The temperature of the penetrant and the surface of the part to be examined shall not be below 04 deg C and not above 52 deg C throughout the examination period. Where it is not practical to comply with these temperature limitations, other temperatures and times shall be used provided the procedures is qualified. The maximum dwell time shall not exceed 2 hr or as qualified by demonstration for specific application. Regardless of the length of the dwell time, the penetrant shall not be allowed to dry. If for any reason the penetrant does dry, the examination procedure shall be repeated, beginning with a cleaning of the examination surface.

8.10 Removal of Excess Penetrant :

After the penetration time specified in the procedure has elapsed, any penetrant remaining on the surface shall be removed, taking care to minimize removal of penetrant from discontinuities

8.10.1 Post emulsifying penetrants.

a) **Lipophilic Emulsification**: After the required penetrant dwell time, the excess surface penetrant shall be emulsified by immersing or flooding the part with the emulsifier. Emulsification time is dependent on the type of emulsifier and surface condition.

The actual emulsification time shall be determined experimentally. After emulsification, the mixture shall be removed by immersing in of rinsing with water. The temperature and pressure of the water shall be as recommended by the manufactured.

b) **Hydrophilic Emulsification**: After the required penetrant dwell time, the parts may be pre rinsed with water spray or directly immersed or sprayed with an emulsifier-water mixture. A pre rinse allows removal of excess surface penetrant from examination objects prior to the application of hydrophilic emulsifiers. hydrophilic emulsifiers work by detergent action. for immersion applications, examination objects must be mechanically moved in the emulsifier bath or the emulsifier must be agitated by air bubbles, so that with either method, the emulsifier comes in contact with the penetrant coating. with immersion, the concentration of the emulsifier water bath shall be as recommended by the manufacturer. For spray application, all part surfaces shall be uniformly sprayed with an emulsifier-water mixture.

With spray applications, the emulsifier concentration shall be in accordance with the manufacturer's recommendation, but shall be no greater than 5%. The final step after emulsification is a water immersion or a water spray post-rinse to remove the emulsified penetrant. All dwell times should be kept to a minimum and shall be not more than 2 min unless a longer time is qualified on a specific part. The pressures (Water emulsifier and water spray) and temperatures (Water and emulsifier) shall be in accordance with the requirements for water-washable penetrants.

8.10.2 Solvent removable penetrants :

Excess penetrant shall be removed by wiping with a clean, dry, lint free cloth or absorbent paper. Repeating the operation until most traces of penetrants have been removed. The remaining traces shall be removed by wiping the surface lightly with cloth or absorbent paper, lightly moisturized with solvent.

8.10.3 Removal of penetrant shall be confirmed in black light.

Caution: Care shall be taken to avoid excess solvent as this may remove penetrants from discontinuities. Flushing the surface with solvent following the application of the penetrant and prior to developing is prohibited.

8.10.4 Water-Washable Penetrants.

a) Excess water-washable penetrants shall be removed with a water spray. The water pressure shall not exceed 50 psi (350 kPa), and the water temperature shall not exceed 110ºF [43ºC).

b) As an alternative to (a), water-washable penetrants may be removed by wiping with a clean, dry, lint-free cloth or absorbent paper, repeating the operation until most traces of penetrant have been removed. The remaining traces shall be removed by wiping the surface with a cloth or absorbent paper, lightly moistened with water. To minimize removal of penetrant from discontinuities, care shall be taken to avoid the use of excess water.

When hydro-air pressure spray guns are used, the air pressure should not exceed 25 psi [172 kPa]

Note: Over washing should be avoided. Excessive washing can cause penetrant to be washed out of discontinuities. With fluorescent penetrant methods perform the manual rinsing operation under black light so that it can be determined when the surface penetrant has been adequately removed.

8.11 Drying :

Drying of surface of the parts is necessary prior to applying dry or non aqueous developers or following the application of aqueous developers.

a) If post emulsifying or water washable method is used, the surface shall be dried by blotting with clean materials or by using circulating warm air, provided the temperature of the surface is not raised above 52 deg C.

b) For solvent removable method, the surface may be dried by normal evaporation, blotting, wiping or forced air.

8.11.1 Application of Developer :

The developer shall be applied as soon as possible after the removal of the excess penetrant. Any of two types of developer, dry or wet, shall be used with fluorescent penetrant.

8.11.2 Application of Dry Developer :

Dry developer shall be applied by a soft brush, a hand operated powder bulb or a powder gun or other means provided the powder is dusted evenly over the entire surface being examined.

8.11.3 Application of wet Developer

Prior to applying suspension type wet developer to the surface, the developer must be thoroughly agitated to ensure adequate dispersion of suspended particles.

a) Aqueous Developer Application:

Aqueous developer may be applied to either a wet or dry surface. It shall be applied by dipping, spraying or other means provided a thin coating is obtained over the entire surface being examined. Drying time may be decreased by using warm air, provided the surface temperature of the part is not raised above 52 deg C. Blotting is not permitted.

b) Non-aqueous Developer Application:

Non-aqueous developer shall be applied by spraying, except where safety or restricted access preclude it. Under such conditions developer may be applied by brushing. Drying shall be by normal evaporation.

8.12 Colour Contrast Penetrant (Visible Dye Penetrants):

8.12.1 With colour contrast penetrants the developer forms a reasonably uniform coating. Surface discontinuities are indicated by bleed-out of the penetrant which is normally a deep red colour. Indication with a light pink colour may indicate excessive cleaning. Inadequate cleaning may leave an excessive background making interpretation difficult.

8.12.2 The minimum light intensity shall be 100 fc. (1000 lx). The light intensity, natural or supplemental white light source, shall be measured with a white light meter prior to the evaluation of indications or a verified light source shall be used.

verification of light sources is required to be demonstrated only one time, documented, and maintained on file.

8.13 Fluorescent Penetrant:

Examination of the surface shall be carried out with a high intensity black light in a darkened area or booth. Black light shall have a wave length of 320 to 380 nm. The bulbs shall be allowed to warm up for not less than 10 minutes prior to use in the examination. The black light intensity shall be minimum 1000 uW/cm2 at a distance of 15 inch (38.1cm) on the surface of the part being examined. The operator should allow his eyes to become accustom to the darkness of the inspection booth for at least 5 minutes before inspecting the parts. He should avoid looking direct into the black light and also avoid going from the darkness to the light and back again without allowing sufficient time for his eyes to adjust to the darkness.

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Note: Examine parts tested with fluorescent penetrant under black light in a darkened area. Ambient light shall not exceed 2 fc [21.5 lx]. The measurement shall be made with a suitable visible light sensor at the inspection surface.

The intensity shall be measured with a black light meter prior to use, when ever the light power source is interrupted or changed and at the completion of the examination or series or examinations. Reflectors and fillers should be checked daily for cleanliness and integrity and, if necessary cleaned prior to use. Cracked or broken filters shall be replaced immediately. Since a drop in line voltage can cause decreased black light output with consequent inconsistent performance, a constant-voltage transformer should be used when there is evidence of voltage fluctuation.

8.14 Observe the surface during the application of the developer to detect nature of any indications which tend to bleed out profusely. Final examination shall be done between 10 minutes at the earliest and 30 minutes at the latest after application of the developer. The nature of discontinuities corresponding to the indications shall be defined depending upon the method of setting, appearance, direction, shape and dimensions of the same. If the bleed out does not alter the examination results, longer periods are permitted. If the surface to be examined is large enough to preclude complete examination within the prescribed time the surface shall be examined in increments.

9.0 Evaluation.

9.1 Analysis:

As the developer dries to a smooth, even white coating, indications will appear at the locations of discontinuities. Depth of surface discontinuities may be correlated with the richness of colour and speed of bleeding out. However, localized surface imperfections such as from machining marks or surface conditions may produce similar indications which are non-relevant.

9.2 Usually, a crack or similar opening will show a line and light cracks or partially welded lap will show a broken line. Gross porosity may produce large indications covering an entire area. Very fine porosity is indicated by random dots.

9.3 Any non-relevant indication shall be regarded as a defect until the indication is either eliminated by surface conditioning or it is proved non-relevant by other NDT methods.

9.4 Linear indications are those indications in which the length is more than three times the width. Rounded indications are indications which are circular or elliptical with the length less than three times the width.

9.5 All indications shall be evaluated in terms of the acceptance standards of the referencing documents.

10.0 ACCEPTANCE CRITERIA:

Acceptance Standard of the indications is as per the acceptance norms as specified in PO specification/Technical specification/Drawing, etc, as applicable. Following acceptance standards are given for reference (for welds).

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10.1 ASME Sect. VIII Div.1

These acceptance standards shall apply unless other more restrictive standards are specified for specific materials or applications within this Division.

All surfaces to be examined shall be free of:

(a) Relevant linear indications;

(b) Relevant rounded indications greater than 3/16 in. (5 mm);

(c) Four or more relevant rounded indications in a line Separated by 1/16 in. (1.5 mm) or less (edge to edge).

10.2 ASME Sect-III-NB/NC/ND

a) Only imperfections producing indications with major dimensions greater than 1/16 in. (1.5 mm) are required to be evaluated for acceptance.

b) Imperfections producing the following indications are unacceptable:

1) linear indications with dimensions greater than 1/16 in. (1.5 mm);

2) rounded indications with dimensions greater than 3/16 in. (5 mm);

3) four or more rounded indications in a line separated by 1/16 in. (1.5 mm) or less edge to edge;

4) ten or more rounded indications in any 6 square in. (4 000 mm2) of surface with the major dimension of this area not to exceed 6 in. (150 mm) with the area taken in the most unfavourable location relative to the indications being evaluated.

11.0 POST EXAMINATION ACTIVITIES:

Surfaces examined shall be cleaned after evaluation of the test with dry cotton cloth with or without water rinse. When post-examination cleaning is required by the procedure, it should be conducted as soon as practical after Evaluation and Documentation using a process that does not adversely affect the part.

12.0 RECORDS :

Record for each examination shall be prepared in a format, attached with this procedure.

13.0 OPERATING EXPERIENCE:

Not Applicable.

Table -1

Applicable method for surface preparation

	Method	Surface preparation	Application of Developer
Weld	A or C	Wire brushing, Grinding, Solvent cleaner	Spraying
Machined Component	A or C	Solvent cleaner, Degreasing, Ultrasonic cleaning	Spraying
Fittings/ Forgings	A or B	Grindings, Machining, Solvent cleaning, Degreasing	Spraying, Dipping for aqueous developer
Castings	A or B	Grinding, Sand blasting, Shot blasting.	Spraying
Non- ferrous Material	A	Machining, Grinding, Solvent cleaning	Spraying
Non metal	A	Solvent cleaning, Degreasing, Detergent cleaning	Spraying

Visible Solvent Removable - A
Visible Water washable - B
Fluorescent Solvent Removable - C
Fluorescent Water washable - D

Table -1A

Applicable method for surface preparation

Surface	Surface preparation
Weld	Wire brushing, Grinding, Solvent cleaner
Machined Component	Solvent cleaner, Degreasing, Ultrasonic cleaning
Fittings/ Forgings	Grindings, Machining, Solvent cleaning, Degreasing
Non- ferrous Material	Machining, Grinding, Solvent cleaning
Non metal	Solvent cleaning, Degreasing, Detergent cleaning

25/10/2017

Table -2

Suggested Penetration and dwell time developer dwelling time for Penetrant Examination General.

Material	Material Form	Type of Discontinuity	Dwell Times (Minutes)	
			Penetrant	Developer
Aluminum, magnesium, Steel, brass and bronze, titanium and high temperature alloys	Castings and welds	Cold shuts, porosity, lack of fusion, cracks (All forms)	5	10
	Wrought materials – extrusions, forgings, plate	Laps, Cracks (all forms)	10	10
Carbide-tipped tools	Brazed or welded	Lack of fusion, Porosity, cracks	5	10
Plastic	All forms	Cracks	5	10
Glass	All forms	Cracks	5	10
Ceramic	All forms	Cracks, porosity	5	10

Development time for final interpretation begins immediately after the application of dry developer or as soon as wet developer coating has dried on surface of parts (Recommended minimum).

Note:01 For temp range from 10ºC to 52ºC.
For temp from 5ºC temp to 10ºC Minimum penetrate dwell time shall be 2 times the value listed.
Unless otherwise specified, the Dwell time shall not exceed the maximum recommended by the manufacturer.

Developing time begins immediately after the application of dry powder developer or as soon as the wet (aqueous or non-aqueous) developer coating is dry (that is, the water or solvent carrier has evaporated to dryness). The maximum permitted developing times shall be four hours for dry powder developer, two hours for aqueous developer and one hour for non-aqueous developer.

Note:02 Where penetrant testing is performed on parts that must be maintained at elevated temperature during examination, special penetrant materials and processing techniques may be required. Such examination requires qualification and the manufacture's recommendations shall be observed.

25/10/2017

FORMAT FOR REPORT

Manufacturer Name & Address

Report for Dye Penetrant Examination

Report No. :
Date :

Procedure No & Rev:					
Manufacture Ref. No.:					
P.O. No / Sub order No. :					
Customer					
Component		Drg. Item No:		Qty	
Drg. No.		Rev. No.			
Specification					
QAP No. :		QAP Clause.			
Material & Thickness		Lighting Equipment			
Surface Condition		Surface Temperature of job			
Test Method		Date & Time of Examination			

	Material Brand & Batch Nos		
Dye penetrant		Penetration Time	
Cleaner			
Developer		Development Time	

Observations (Including recording and mapping of indications):

Conclusions (for acceptability/unacceptability):

Tested	Reviewed	Accepted
by :	**by :**	**by :**
Level :	**Level :**	**Level :**
Date :	**Date :**	**Date :**

Notes:

1. Material: Only approved material for dye penetrant testing to be used and to be reported.

25/10/2017

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)

DIRECTORATE OF QUALITY ASSURANCE

DOCUMENT NO: QAD/NDT-PROC/PT/05 Rev.: 3

TITLE	PROCEDURE FOR APPROVAL OF FAMILY OF CHEMICALS USED FOR LIQUID PENETRANT EXAMINATION

REVISION NO.	0	1	2	3
DATE OF ISSUE (Month/Year)	March 2001	April 2007	June 2013	June 2017
TOTAL NO. OF PAGES (Including cover sheet)	11	14	14	16

REVISION CONTROL SHEET

PROCEDURE FOR APPROVAL OF FAMILY OF CHEMICALS USED FOR LIQUID PENETRANT EXAMINATION

DOCUMENT NO.: QAD/NDT-PROC/PT/05 Rev.: 3

Rev. No. & Date	Description of Revisions		
R-0 & 01.05.1999	**Description of Revision:** Original		
	Prepared by D.D.Agrawal	**Reviewed by** Y.P.Abrol	**Approved by** S.Vaidyanathan
R-1 & 05.01.2000	**Description of Revision:** Para nos. 1.0,4.0,5.1 to 5.9 & 6.0 amended Earlier clause 5.8 to 5.9 amended to 5.9 and 5.10 respectively. Clause no.5 .8 added. Cover page amended and amendment record sheet added.		
	Revised by D.D.Agrawal	**Reviewed by** S.Gurnathan & A.K.De	**Approved by** Y.P.Abrol
R-2 & April, 2012	**Description of Revision:** Revision control sheet added .Para5.1.1, 5.1.2, 5.1.3 Para 5.1.4 and 5.2.0 added. Para no.5.6.1 and 5.6.2 has been addressed in para no. 5.2.1.1 and 5.2.1.2 respectively. 5.2.1.1(ii) modified and 5.2.1.2(vi) added. Para nos. 5.8,5.9,5.10 and 6.0 modified and shifted in para nos. 6.0,7.0,8.0 and 9.0 respectively. Letter of approval modified .Check list for audit added.		
	Revised by A.K.DE	**Reviewed by** N.P.Srivastava	**Approved by** K.P.Dwivedi
R-3 & June, 2017	**Description of Revision:** Procedure no. QAD/proc/DP Chemicals/001 is re-numbered as QAD/NDT-PROC/PT/05. Para 5.1.1 (v) minimum NDT Personnel qualification criteria changed. Some editorial changes done.		
	Revised by 29/6/2017 (B.B.Bhandari)	**Reviewed by** 30.06.17 (Sunder Singh) (A.K.Singh)	**Approved by** 10.07.2017 (L.K.Jain)

1.0 Purpose :

Procedure to be followed for approval of family of chemicals used for Liquid Penetrant examination for NPCIL jobs.

2.0 Scope:

This procedure covers the chemicals used for the following Liquid Penetrant examinations:

(i) Solvent removal technique – visual and fluorescent
(ii) Water washable technique - visual and fluorescent

3.0 References :

(i) ASME BPVC Section V, Article 6 including Appendixes for “Liquid Peneratant Examination”.
(ii) ASME BPVC Section V, Article 24SE-165 for “Standard Practice for Liquid Penetrant Examination for General Industry”.

4.0 Responsibility:

Group/Section Head of Co-ordinating office and executing office

5.0 Description :

5.1 Stage I evaluation :

5.1.1 A request from manufacturer for approval of their brand of chemicals for Liquid Penetrant Examinations is received by Group/Section Head, co- coordinating office for approval. A checklist (prepared based on following criteria) is sent by Group/Section Head, co-ordinating office to manufacturer for filling up. The filled up checklist is received by Group/Section Head, co- coordinating office for acceptance/approval. Annexure-B can be use as Checklist.

Eligibility criteria for approval: Manufacturer shall meet the following criteria for approval of the brand of chemicals for Liquid Penetrant Examination.

(i) Established, implemented and maintained documented Quality management System (QMS) as per ISO 9001 or any other national and international standard. The QMS shall be certified by recognized certifying agency and the certificate shall be valid.

(ii) Established in the market for last three years for the specific brand of consumable.

(iii) Methodology of defining batch of Penetrant, Cleaner and Developer.

(iv) Availability of in-house facilities for all measurements and tests.

(v) Availability of competent QC and NDT personnel having certification from ISNT/ASNT Level- III (with a minimum experience of 5 Years) or Level- II (with minimum experience of 10 years) in DPT.

(vi) Availability of test methods and control values for specific gravity, viscosity, flash point, solid content and setting rate for developer.

(vii) Availability of proper labels on containers having information about method of testing, manufacturer's name, brand name, batch no., date of manufacturing, expiring date as a minimum.

(viii) Availability of calibrated measurement and test equipment with NABL accredited lab certificate, calibrated at specified frequency.

5.1.2 After review of checklist and if found suitable, the Manufacturer shall be asked to submit the following documents for further review.

(i) QMS Manual

(ii) Process Flow chart

(iii) Organization chart along with responsibility and authority of key personnel

(iv) Inward material control , In process control, Finished product control

(v) Quality Assurance Plan

(vi) Procedure on identification and traceability

(vii) Production for last three years to be submitted customer (end users) wise.

(viii) List of machineries used for production

(ix) List of measuring and test equipments along with their calibration status.

(x) Test results of final product for the last 6 months.

(xi) Copy of ISO certificate

(xii) Customer feedback

(xiii) List of authorized main dealers/sub dealers /vendors etc.

(xiv) Location of factory along with covered and open areas, contact details etc.

5.1.3 The documents submitted by manufacturer are reviewed by Group/Section Head, Coordinating office for approval. While reviewing the documents, it is ensured that Manufacturer should have documented Quality Management System (QMS) which should spell out how quality is ensured during Inward material control, In-process control and finished product control. It should clearly indicate acceptance standard, method of defining a batch, method of packing, proper labels on the containers etc. It should also indicate as a minimum on label of the container ,method of testing , manufacturer 's name, brand name, batch no., date of manufacturing, expiring date, temperature range at which LPE can be conducted etc..QMS documents should also include test methods and control values for properties such as specific gravity, viscosity, flash point, solid content and setting rate for developer. Quality Assurance Plan should indicate quality characteristics to be checked during in-coming, in-process and final stage of products, reference documents to be followed along with acceptable criteria, inspection agency to be involved, format of records etc. The testing of chemicals shall be witnessed by manufacturer's QC, certified by PT Level-III personnel or by a PT level-II with minimum 10 years of experience in penetrant examination.

Production of each brand of chemicals for Liquid Penetrant Examination:

Manufacturer shall submit the production quality of each brand customer-wise (end users) for the last three years. The manufacturer should establish in the market for at least last three years before applying to NPCIL for approval of the brand. They should also give justification for downward trend (if any) in production or in sales of the brand in last three years. Customer feedback (if any) shall also be submitted.

5.1.4 After reviewing the above documents in the light of requirement stated in 5.1.3 above and when it is adequate, a report is issued by group /section Head, co-ordinating office /his or her authorized personnel and forwarded to ED(QA) .

Invoice is sent to manufacturer for payment pertaining to charges for approval of chemicals for Liquid Penetrant Examination. After obtaining the payment from manufacturer, then stage-II evaluation can be proceeded with.

5.2.0 Stage –II evaluation:

After receiving request letter from Group Head/section Head, co-ordinating office, this stage is carried out by Group Head/section Head, co-ordinating office QA office or QS engineer authorized by him/her. For manufacturer located at Mumbai, this stage is carried out by Group Head/section Head, co-ordinating QA office or QS engineer authorized by him/her. In this stage, verification is carried out about implementation of QMS programme of the manufacturer and witnessing of all the tests as mentioned in the paragraphs mentioned in para 5.2.1.1 & 5.2.1.2. Report is to be forwarded along with the records of tests carried out and inspection reports to Group/section head co-ordinating for approval.

5.2.1 Chemicals used for Liquid Penetrant Examination shall be tested as follows:

5.2.1.1 Test for Penetrant , Cleaner and Developer :

(i) Sensitivity Test :

Nickel chrome test panel can be used for determining penetrant sensitivity. The panels are classified accordingly to the size of crack they contain. The panels are of grades coarse, medium and fine. The coarse panels provide low sensitivity, medium panel provide medium sensitivity and fine panels provide high sensitivity. Panels shall be examined as per method recommended by manufacturer.

Generally dwell & development time of 10 minutes for solvent removable penetrant and dwell time & development time of 20 minutes for water washable penetrants is considered adequate. Colour contrast penetrants shall be tested using panel having 2 microns wide x 50 microns deep cracks. Fluorescent penetrant shall be tested using 1 micron x 10 microns panel. All the cracks as indicated in the reference photographs shall be visible.

(ii) Chemical analysis :

Control of residue percentage is special important in selection of a particular penetarnt for specific job. Cleaner, penetrant and developer are tested for ionic halogen and total sulphur(as sulphate). Ionic halogen and sulphur content should not exceed 25 ppm and 500 ppm respectively. When using penetrant material on austenitic stainless steel, titanium, nickel – base or other high-temperature alloys, ionic sulphur and halogens should not exceed more than 25 ppm for Nuclear (NPCIL) applications. Manufacturer may produce separate brand for this application.

(iii) Corrosion Test:

Control of residue percentage is of special importance in selection of a particular penetarnt for specific job. Penetrant, cleaner and developer must not react with metals to cause cracking, pitting or any other damage to materials on which test is done.

Samples of various materials such as SS, CS, Copper, Brass and aluminum which are commonly used for NPCIL jobs are dipped in cleaner, penetrant and developer and kept for 48 hrs minimum. On cleaning there should be no indication of any pitting or any other damage.

5.2.1.2 Test for Penetrant only :

(i) Miniscous Spot Test :

This test is carried out using a flat white plate or a tile and a planoconvex lens having radius of 1.06 mtrs. Few drops of penetarnt are put on the tile and planoconvex lens is kept on it and the dimension of central colourless white spot is measured. This dimension should not exceed 4.0 mm and 2.5 mm for colour contrast penetrants and fluorescent penertants respectively.

The black light intensity for fluorescent penetrants should be between 1000 to 3000 micro watts/cm2 at a distance of 15 inch. and wave length shall be 320 to 380 nm. For visible dye penetrant minimum light intensity at a examination surface should be kept 1000 lux.

(ii) Colour stability Test:

The lens in miniscous spot test is kept for 1 hour for fluorescent penetrant OR visible dye penetrant as applicable. After lapse one hour the miniscous spot shall be checked under black light of intensity 3000 microwatt/cm2 for flourascent dye and for visible dye penetrant (under light intensity of 1000 lux minimum). There should not be any increase in miniscous spot size as mentioned in para 5.2.1.2 (i)

(iii) Drying Test:

Two methods are used for conducting this test:

In the first method, when the lens is removed after conducting colour stability test, the penetrant must flow and make a uniformly thick spot on the tile.

In the second method, a small quantity of penetrant is spread on the tile and allowed to remain there for 1 hour. After one hour, the tile is tilted. The penetrant must flow.

(iv) Colour Contrast Test:

This is a qualitative test. The indications found during sensitivity test should have very good colour contrast. For this purpose, indications are compared with earlier approved brand of penetrant.

(v) Water Washability Test:

This test is required only for water washable penetrant. In the water washablity test, the washability performance of the penetrant tested with respect to the reference penetrant. The penetrant are applied to separate test panel. After normal dwell time and draining periods, the penetrant to be washed from panels using uniform water spray.

The temp of water shall be maintained within the range of 10 to 30 deg.C and spray and rinse water pressure shall not exceed 40 psi. If washing is found to be difficult, or retention of background dye is noticeably different from that of the reference penetrant, the penetrant shall be rejected. Other suitable methods may also be considered.

These penetrants are allowed to be used where proper cleaning of solvent removable penetarnt is not possible and results into heavy back ground such as a for casting, forging , CS pipe fittings etc. To carry out the test carbon steel pipe fittings are tested using standard test procedure and there should not be excessive back ground. Also it should not be milky white indicating excessive washing.

vi) Application of penetrant for non standard temperature:

When manufacturer mention suitability of penetrant material beyond temperature range 5 to 52^0 C, then penetrant material shall be qualified at the minimum temperature below 5^0 C and maximum temperature above 52^0 C as per Appendix III of article 6 of ASME section V.

6.0 Approval and Certification:

Subsequent to the testing report shall be issued by the concerned Group/Section Head, executing office or his /her authorised QS engineer and copy of report along

with all the test reports/ test certificates shall be forwarded to Group/Section Head, co-ordinating for approval who shall process them for approval. After acceptance of the above reports, the "Letter of Approval" shall be issued by Executive Director (QA). Each "Letter of Approval" shall be numbered as NPC/QAD/Appr/DP Chem/running sr.no. Format of letter of the approval should be as per Annexure -A.

Re-approval: For re- certification of the brands of chemicals for Liquid Penetrant Examination, vendor shall be intimated well in advance (at least 6 month) before the date of expiry for re-certification of brands by Group/section head, co-ordinating office.

Documents as mentioned in para 5.1 shall be enclosed along with the request by vendor for re-approval. The re-approval shall be done based on review of documents and carrying out audit on the vendor to verify implementation of documents submitted /testing a per this procedure or both as decided by Group /Section Head , co-ordinating office for approval based on past track record of vendor.

In case of testing is carried out for re-approval by manufacturer as per the procedure and witnessed by NPCIL. Invoice is sent to manufacturer for payment pertaining to charges for re-approval of chemicals for Liquid Penetrant Examination. After receiving the payment from manufacturer, then letter of re-certification shall be issued to manufacturer.

6.1 Deviation to the procedure:

Approval of ED (QA) shall be sought in case of deviation is taken from this procedure.

7.0 Validity:

Validity of approval is for a period of 5 years from the date of issue of "Letter of Approval" Thereafter, manufacturer may be audited once after 2 years from the date of approval or the date of last audit or as decided by Group/Section Head, co-ordinating office. Continuation of the approval shall be decided based on the audit performance. In case of any adverse comments from users against deterioration of quality of penetrant/cleaner/developer material, the manufacturer shall be communicated in writing about the deviation in product quality. Manufacturer should also have record of complaint, the reasons for the deviation, root cause analysis, correction and corrective action taken/to be taken. They shall be asked to submit the above documents. Subsequently they shall be audited to verify further the implementation of quality management systems, corrective action for the same and meeting the product quality. **The approval shall be withdrawn any time if**

deterioration in quality is observed till implementation is found satisfactory after audit.

8.0 Approval list:

List of approved brands of DPT chemicals mentioning the name of manufacturer, validity period etc. shall be issued by Group /Section Head, co-ordinating for approval once in six month to all QA offices, engineering and procurement directorates, site and stations. This list is also kept in QAD intranet web Home page under "Approved List". This list is updated periodically once in six months by QAD Mumbai.

9.0 Records (To be kept by Group /section Head , Co-ordinating office) :

(i) Review report for stage-1
(ii) Report for brand approval along with reports/certificates for Stage-II
(iii) Audit report
(iv) Letter of approval
(v) Request for approval, filled in checklist along with documents submitted by manufacturer.

Annexure A

QAD Letter Head

NPCIL/QAD/Appr./DP chemical/running s.r no. Date:

LETTER OF APPROVAL

Subject: Approval of chemicals used for Liquid Penetrant Examination on NPCIL jobs.

This is to certify that the following brands of chemicals used for Liquid Penetrant Examination have been tested in accordance with the NPCIL procedure for approval of chemicals used for Liquid Penetrant Examination and found satisfactory.

Name of vendor:

Address:

Sr.No.	Brand Name	Description

The above brands are approved for use on NPCIL jobs.

This approval is valid up to _____ .Within the approval period, vendor may be subjected to periodic audits by NPCIL, or his authorized personnel. Based on the performance in the audits, approval shall be continued till the validity period. This approval shall also be reviewed in case any quality problem is brought to our notice. The approval shall be withdrawn at any time if deterioration in quality is observed.

Executive Director (QA)

Copy to:

Group /section Head , Co-ordinating office
Group /section Head , Executing office

Annexure B

Check list for audit on manufacturing for approval of family of chemicals used for Liquid Penetrant Examination

Sr. no.	Para no. of documents	Observations	Remarks
01	QMS Manual	**Look at**: Organization chart if separately issued and compare this with the chart mentioned in the QMS manual. **Look at**: Level of top management to whom QA Head is reporting? **Look at:** Whether QA Head and production Head are independent? **Look for :** Responsibilities and authorities are defined for all functions and levels **Look for:** Responsibilities and authorities as stated are being exercised by QA Head.	
02	Documents and records control procedure	**Look at:** Latest copy of QMS documents. **Look for :** Availability of the same and distributed to controlled copy holder **Look at :** Authority for preparation, review and approval of documents **Look for:** Signature of authorized personnel in the documents.	
03	a) Quality Assurance Plan. b) NPCIL Procedure for approval of chemicals for Liquid Penetrant examination	**Look at :** QAP **Look at :** Batch for each chemical for LPE **Look for :** Each batch is tested **Look at :** Test results confirm to the requirement **Look at :** In- coming , in-process and final testing as per QAP **Look for :** All stage inspection reports are available **Look for :** Inspection reports for inspection stage as per QAP **Look at:** Results conform to requirements and	

		signed by authorized personnel.	
04	Inspection and testing	**Look at :** Incoming , in-process and final inspection (with regards to review point , witness point or hold points) are conducted as per QAP. **Look for :** Inspection and testing of items, services and processes are carried out using established acceptance and performance criteria **Look for :** Stage inspection records are properly made, complete in all respect ,clearly indicating the status of inspection i.e. acceptance/acceptable with remarks /not acceptable/deviation to be regularized etc. Records are co- relatable with the jobs. **Look for:** Inspection personnel are independent of manufacturing activity?	
05	Quality Manual	**Look at :** Procedure for approval of sub-vendors **Look for :** Evaluation report for sub-vendors and list of approved sub-vendors	
06	Vendor Procedure for identification and traceability	**Look at :** Identification and traceability procedure **Look for:** How batch no. of chemicals are mentioned? **Look for:** Whether for particular batch no. assigned to chemicals can be traced back to batch no. of raw material, batch no. of individual ingredient etc.?	
07	Vendor procedure for Preservation of product	**Look at :** Preservation of product procedure **Look for:** Preservation of chemicals for LPE. Whether it is as per procedure?	
08	List of teat equipments and measuring devices submitted to NPCIL	**Control of monitoring & measuring devices** : **Look at:** List of test equipments and measuring devices submitted to NPCIL **Look for:** Availability of the same as per the list submitted to NPCIL. **Look for:** All the required tests and measuring	

		facilities required as per NPCIL procedure are available **Look at :** Calibration status of measuring and test Equipment **Look for:** Validity of measuring and test equipment **Look for :** calibration records of measuring and test equipment	
09	Customer feedback taken/Customer complaint	**Look at:** Customer feedback taken /Customer complaint received. **Look for:** Whether feedback is taken from end users. **Look for:** Attending of customer complaint, reason for deviation, root cause analysis, identification and implementation of corrective action.	
10	Inspection audit procedure	**Look at :** Internal audit procedure **Look for :** Internal audit is being conducted as per documented procedure for all functions as per specified frequency. **Look for :** Implementation of audit observation and disposition of non- conformance if any. **Look at :** MRC report **Look for :** Implementation of the same.	
11	Non conformance control procedure	**Look at :** Non-conformance of product and system **Look for :** Disposition of non-conformance	
12	Corrective & Preventive action procedure	**Look at**: Corrective & preventive action procedure. **Look for**: Corrective actions against non-conformance /customer complaint/adverse feedback is taken. **Look for:** Any preventive action identified and taken	

13	Management review	**Look at :** Appointment of MR **Look for :** All responsibility as mentioned in the manual are being complied with **Look at :** Agenda of MRC in the manual **Look for:** Whether all agenda points were discussed in the meeting? **Look at :** Earlier MRC M.O.M **Look for:** any pending issues are there. **Look at :** Monitoring implementation of MRC **Look for** : Implementation of the same.	
14	List of machineries for production, submitted to NPCIL	**Look at :** List of machineries for production, submitted to NPCIL **Look for :** Availability of status for the same as per list submitted	
15	Production of each brand for the last three years	**Look at**: Last three years production of each brand **Look for:** How much the quality produced vs delivered to each customer for each year for the last three years? **Look at :** POs received by vendor **Look for**: Whether repeat orders are placed? Whether the brand is established in the market for the last three years?	
16	Competence of personnel	**Look at :** Skilled matrix /work authorization **Look for :** Competence of Head QA of vendor and its personnel based on documents submitted and /or interviewing them. **Look for :** Awareness of test requirement as per procedure? **Look for** : Level –III/II certification on PT from ISNT/ASNT **Look for:** Experience of personnel on PT	
17	Witnessing tests as per the procedure for chemicals for LPE	**Look at :** Capability for preparation of test coupons as per procedure. **Look for :** Capability for carrying out all test as per their manufacturer ’s procedure. **Look for :** Method of testing is same as mentioned in the level affixed on the container.	

		Look at : Tests to be carried out as per the NPCIL procedure **Look for :** Witnessing of all the tests. **Look at :** Markings required on level to be attached on container for Penetrant, Cleaner and Developer. **Look for :** Marking on levels and packing **Look at :** Precautionary information on level affixed on container as per the requirement of ASME section V or NPCIL Specification (if applicable) **Look for :** The same is complied with	

Note : This checklist is not exhaustive and is given for guidance only. This can be suitably modified by auditor as needed and attach the same with the report.

Signature
(Auditor)

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

DOCUMENT NO: QAD/NDT-PROC/RT-01 R2

TITLE	PROCEDURE FOR RADIOGRAPHY EXAMINATION OF WELDS

This procedure can be used as reference procedure. A "Technique Sheet/Job specific procedure" is to be prepared identifying the NDT process variables and identifying "Acceptance criteria" (NPCIL Specification / Code clause) for a given application by the User/Vendor.

REVISION NO.	0	1	2
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PROCEDURE FOR RADIOGRAPHIC EXAMINATION OF WELDS

DOCUMENT NO: QAD/NDT-PROC/RT-01 R2

Rev. No. & Date	Description of Revisions		
PP-E-2356 R 0 (June. 2007)	**Description of Revision: Original**		
	Prepared by N.P.Upadhyay	**Reviewed by Sundar Singh, A.K.Srivastava**	**Approved by K.P.Dwivedi**
PP-E-2356 R 1 (Sept. 2012)	**Description of Revision: Editorial changes and changes as per latest codes/ Standards**		
	Revised by N.P.Upadhyay	**Reviewed by Sundar Singh**	**Approved by K.P.Dwivedi**
QAD/NDT-PROC/ RT-01 R2 (June 2017)	**Description of Revision:** Procedure No changed to QAD/NDT-PROC/RT-01 R2. Provision for Job Specific procedure/Tech Sheet is added. Wire type IQI designation added as Table 2. Equivalent Hole type IQI sensitivity added as Table 4. Latest and legible figures added from latest codes as Fig 1 and Fig 2 and Fig 6 to Fig8. Minor editorial changes done. Sample RT Technique sheet is added.		
	Revised by	**Reviewed by**	**Approved by**
	30/6/17 **R V Kamble** **RT-Level – III**	30.06.2017 **S Viswanath** **RT-Level – III** **A.K.Singh, AD(QA)** 10/7/17	10/7/17 **L K Jain** **ED(QA)**

1.0 SCOPE:

This general RT procedure describes the requirements to be followed and acceptance criteria for the examination of welds for discontinuities using Radiographic Techniques.

This procedure applies to all welded material parts, components and repairs when radiographic examination is required by NPCIL Specifications. The term "Radiographic Techniques" shall include both X-Ray and Gamma Ray techniques.

*This procedure can be used as reference procedure. A **Technique Sheet** is to be prepared identifying the NDT process variables and identifying "Acceptance criteria" (NPCIL Specification/Code clause) for a given application by the User/Vendor. (Sample RT Tech Sheet attached)*

1.1 Contents:

The requirements of this procedure are presented under the following sections:

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2.0 APPLICABLE DOCUMENTS AND STANDARDS:

The following documents and standards of the issue in effect, form a part of this procedure to the extent specified in this document.

a) ASME Sec. III Division I. - Boiler and Pressure Vessel Code for Nuclear Equipments.

b) ASME Sec. V Article 2 - Radiographic examination.

c) ASME Sec. VIII Div . 1 - Boiler and Pressure Vessel Code.

d) ASME Standard SE 94 - Standard Guide for Radiographic Examination

e) ASTM Standard E 1032 - Test method for radiographic examination of weldments

3.0 QUALIFICATION OF RADIOGRAPHIC EXAMINATION PERSONNEL:

All the personnel performing radiographic examination shall be qualified in accordance with recommended guideline of SNT-TC-1A of ASNT/IS-13805/ISO 9712-3./BARC

Radiography shall be performed by personnel qualified by BARC to RT level I or II. The test results shall be evaluated by either level II or level III qualified personnel.

4.0 SAFETY PRECAUTIONS:

All the precautions with regards to radiation safety shall be observed strictly as per the guidelines of AERB/BARC/National Codes and Guides.

The radiography examination involves use of ionizing radiations (X-Ray & Gamma). For the potential risk associated with acute radiation exposure and health hazard, all the personnel engaged in radiography examination, handling of equipments and people working around the job shall be made aware of the necessary protective measure as recommended in above safety Codes/Guides.

5.0 GENERAL REQUIREMENTS:

Radiographic examination is employed for detection of internal discontinuities such as cracks, voids, porosity, inclusions, inadequate penetration, lack of fusion etc.

The manufacturer, of a product to which this procedure is applicable, shall provide for and perform all the inspection and testing specified herein which is appropriated to the product or is demanded by the controlling product specifications, purchase order or drawing. The radiography examination shall be conducted in accordance with written Job specific procedure/Technique Sheet and shall be subjected to approval by Nuclear Power Corporation of India Limited (NPCIL).

5.1 Procedure Requirements:

The written procedure / Tech sheet shall contain, as a minimum, the following technique variables: **(Refer Sample technique sheet)**

- Material and thickness range
- Isotope used or maximum X-Ray voltage
- Minimum source to film distance
- Maximum source size
- Film brand or designation
- Screen used etc

Demonstration of density and penetrameter image requirements of the written procedure on production radiographs or technique radiographs shall be considered a satisfactory compliance of the procedure.

5.2 Surface Preparation:

5.2.1 Welds:

The weld ripples or the weld irregularities on both inside (accessible area) and outside shall be removed by any suitable process to such a degree that resulting radiographic image due to any irregularities cannot mask or be confused with the image of any discontinuity.

5.2.2 Surface Finish:

The finished surfaces of all the butt-welded joints may be flush with the base material or may have any reasonably uniform crowns. The weld reinforcement shall not exceed the specified limits of the referencing code.

5.3 Back Scattered Radiation Check:

A lead screen of adequate thickness is placed behind the part under radiography to reduce back scattered radiation. As a check on back scattered radiation a lead symbol 'B' with minimum dimension of ½ inch (13 mm) in height and 1/8 inch (3 mm) in thickness shall be attached to the back of each film holder during exposure. If a light image of the lead letter "B" appears on the radiograph, it indicates that more back scatter protection is necessary. The appearance of a dark image of the lead letter "B" should be disregarded, unless the dark image could mask or be confused with rejectable weld defects.

5.4 Radiographic Identification and Marking:

a) A system of positive identification of the film shall be provided. As a minimum, the following shall appear on the radiograph; the name or symbol of company performing radiography, the date and the weld identification numbers traceable to part and contract.

b) Exact location of area of interest should be marked and hard punched on the surface of the part/weld seam for permanent identification during and after radiographic examination. Location markers or letters made of lead or high atomic number metal should be placed on the part under examination and not on the film holder. Their images shall clearly appear on the radiograph.

c) Utmost care shall be taken that identification letters do not interfere in the evaluations of results and provide sufficient evidence on the radiograph that complete coverage of the area being radiographed has been obtained with following exceptions:

   i) The method of marking identification letters shall not be injurious to the component.

   ii) In case, where permanent stamping is impractical or prohibited a temporary marking on the surface of the component or part shall be made. It is important that in such cases, an accurate sketch clearly showing all the temporary marking shall be maintained until satisfactory examination of the part is established.

iii) Repaired area shall be identified with the letter "R-1" for the first repair and "R-2" for the second repair and complete identification shall appear on the radiograph. The radiographs taken after repair shall be presented for evaluation along with original radiographs.

5.5 Monitoring Density Limitation of Radiographs:

Either a step wedge comparison film or a densitometer shall be used for judging film density. A calibrated step wedge film traceable to a national standard shall be used to calibrate a densitometer.

5.6 Extent of Examination:

Unless otherwise specified by purchaser and supplier agreement, the extent of radiography shall include the 100% of the volume of the weld.

6.0 MATERIAL AND EQUIPMENT:

6.1 Radiography Apparatus:

Radiation source (X-Ray or Gamma Ray): Selection of the appropriate source is dependent upon variables regarding the weld being examined (material composition and thickness). The suitability of source shall be demonstrated by attainment of the required IQI sensitivity and compliance with all other requirements such as film density, area of interest density tolerances.

6.2 Film

6.2.1 Selection:

Radiographs shall be made using good quality industrial radiographic films meeting the image quality requirements of this procedure or as specified in purchaser and supplier agreement.

Various industrial radiographic films are manufactured to meet quality level and production needs. Test method ASTM E-1815 provides a method for film manufacturer classification of Film System. A Film System consists of the film and associated film processing system. A choice of film class can be made as provided in test method ASTM E-1815.

Following are some of the commercially available industrial radiography films which may be used for performing radiography of welds as per this procedure provided sensitivity requirements are met (Films of equivalent class of other manufacturers may also be used provided radiographic sensitivity meets the specified requirements):

Sr No	CLASS	FILM CODE			
		KODAK	LASER	AGFA	FUJI
1.	Special (Ultra fine grain, very high contrast used for highest quality radiographs).	DR50	-	D2	IX25
2	I (Extra fine grain, very high contrast used for highest quality radiographs).	M100, MX125 & T200	NDT 3, NDT 4, NDT 5	D3, D4 & D5	IX50 & IX80
3.	II (Fine grain, high contrast suitable for light metals with low energy).	AA400	NDT 7	D7	IX100

6.2.2 Film care:

Radiographic film shall be free from blemishes. Unexposed film shall be stored in such a manner that they are not exposed to light, pressure, radiation, excessive humidity, heat or chemical contamination.

6.2.3 Film processing:

For film processing main Equipments & Chemical required are developer, stop bath, fixer, washing agent and drying equipment. Method of processing and selection of chemical shall be as per recommendations laid by the manufacturer of film. Chemical processing baths such as developer, stop bath and fixer shall be maintained in the fresh or replenished condition. Processing Tanks shall be made of stainless steel material.

The object of film processing is to transform the invisible latent image produced on the film by X-Rays or Gamma Rays to a visible and permanent image. Following are the main steps involved in film processing:

a. Development
b. Stop bath
c. Fixation
d. Washing
e. Drying

Automatic or Manual film processing method may be selected for processing the radiography films. The film Image Quality will vary with the processing variables such as chemistry, temperature, time and method of processing (Manual or Automatic). The film processing requirements shall be in accordance with Guide ASTM E-999.

6.3 Screens:

6.3.1 Lead foil screens should be used in direct contact with the films in all gamma radiography during exposure. Lead foil screens of appropriate thickness should be used whenever they improve the quality of radiography or penetrameter sensitivity or both. The thickness of

the front lead screens should be selected with care to avoid excessive filtration in the radiography of thin or light alloy materials.

For radiography using gamma sources the thickness of the front lead screen should be 0.13 mm for Ir-192 and 0.13 mm to 0.25 mm for Co-60. Minimum thickness of the back lead screen shall be 0.13 mm for Ir-192 and 0.25 mm for Co-60. **Fluorescent screens shall not be used for radiography.**

6.3.2 Screen care- All screens should be handled carefully to avoid dents and scratches, dirt, or grease on active surfaces. Grease and lint may be removed from lead screens with a solvent. The screens showing evidence of physical damage should be discarded.

6.4 Image Quality Indicator (IQI):

IQI shall be either the hole type or the wire type. IQI design, manufacture and material grouping shall be as per ASTM E-747 and ASTM E-1025 for wire type and hole type respectively. ASME standard hole type penetrameters shall consist of those as specified in Table-1.

6.5 Viewing Room and Facilities for Viewing of Radiographs:

The radiographs shall be viewed in a room illuminated by subdued back ground lighting. Room illumination must be arranged in such a manner that will not cause reflections, shadows, or glare on the radiographs. Equipment used to view radiographs shall provide a light source sufficient for the essential penetrameter hole to be visible for the specified density range and shall permit the viewing of the radiographs with an optical density of 4.0.

7.0 CALIBRATION

7.1 Source Size:

7.1.1 Verification of source size:

Equipment manufacturer's publications such as technical manuals, decay curves or written statements documenting the actual or maximum source size or focal spot shall be acceptable as verification of source size.

7.1.2 Determination of source size:

When manufacturer's or supplier's publications are not available, source size may be determined as follows:

a) X-Ray Machines: For X-Ray machines operating at 500 KV and less, the focal spot size may determined by the Pin-Hole method, in accordance with ASME SE-1165, Standard Test Method for "Measurement of Focal Spot of Industrial X-Ray Tubes by Pin Hole Imaging".

b) Iridium-192 Sources: For Iridium -192 the source size may be determined in accordance with ASME SE-1114, Standard Test Method for "Determining the Focal Size of Iridium-192 Industrial Radiography Sources".

8.0 EXAMINATION PROCEDURE:

Radiography shall be performed according to a radiographic shooting sketch showing source location, film position, and location of the penetrameter. The radiographic shooting sketch shall be annexed to the written procedure for approval by NPCIL.

8.1 Radiographic Technique:

8.1.1 Single-Wall Technique: (Refer Fig.1)

Radiography, regardless of the configuration of the product, shall be performed using a single wall radiographic technique whenever practicable. The radiation passes through only one wall of the weld (Material) which is viewed for acceptance on the radiograph. An adequate number of exposures shall be made to demonstrate that the required coverage is obtained.

8.1.2 Double-Wall Technique: (Refer Fig.2)

Whenever single wall technique is not practical, one of the following double wall techniques shall be employed. (Ensure 100% coverage is achieved, when required)

a) Single-Wall Viewing:

Radiography of circumferential butt welds shall be performed with single-wall viewing only; the radiation passes through the both walls. The weld/material on the film side wall is only viewed for examination. When complete coverage is required for circumferential welds and for materials, a minimum three exposures 120^0 apart shall be taken.

b) Double-Wall Viewing:

(1) Unless otherwise specified, for material and welds in pipe and tube 3.5 inch (89 mm) or less in nominal outside diameter, radiography may be done using a technique in which radiation passes through two walls and the weld in both walls is viewed for acceptance on the same radiograph.

(2) The radiation beam may be off set from the plane of the weld centre line at an angle sufficient to separate the images of the source side and film side portions of the weld so that there is no overlap of the areas to be interpreted. When complete coverage is required, a minimum of two exposures taken at 90^0 to each other shall be made for each weld joint. This technique is also known as elliptical technique.

(3) As an alternative, the weld may be radiographed with the radiation beam positioned so that the images of both walls are super imposed, in which case a minimum of three exposures shall be taken at 60^0 at each other.

(4) For double wall viewing only source side penetrameters shall be used and selection made from Table-2 shall be based on single wall thickness.

8.2 Selection of energy of radiation

8.2.1 X – Ray Radiation:

The maximum voltage used in the radiographic examination shall not exceed the value that is shown in Figure 3 for steel, Figure 4 for alloys of copper and/or high nickel, Figure 5 for aluminium and aluminium alloys. For materials other than shown in Figure 3, 4 and 5 the voltage selected shall be in accordance with the procedure qualification and demonstration.

8.2.2 Gamma radiation:

The recommended minimum thickness for which radioactive isotopes may be used is as follows:

Material	Minimum Thickness	
	Radiation Source	
	Iridium 192	**Cobalt 60**
Steel	0.75 inch (19 mm)	1.50 inch (38 mm)
Copper or high nickel	0.65 inch (17 mm)	1.30 inch (33 mm)
Aluminum	2.5 inch (64 mm)	-

The maximum thickness which can be radiographed with above radioactive isotopes is primarily dictated by exposure time, hence upper limits are not shown. It is recommended that minimum thickness limitation may be reduced and radiographic techniques used shall demonstrate that the required penetrameter sensitivity is obtained.

8.3 Radiographic Technique Control:

a) Each cassette or film holder shall be placed on the surface to be radiographed in a secured manner so that there is a minimum gap between the surface of interest and the cassette. When film cassettes are overlapped the minimum overlap shall not be less than one inch from each end of the cassette. When practical, the film shall be shaped to the contour of the object.

b) As a check on the radiographic technique employed penetrameters shall be used in a manner as described to determine whether the requirements are met. All radiographic examination performed shall be proved by actual demonstration.

c) The source to object distance shall be selected in such a way that a sharp image is produced.

8.4 Direction of Radiation:

The direction of central beam of radiation should be centred on the area of interest whenever practical.

8.5 Geometric Un-sharpness:

Geometric Unsharpness of the radiograph (Ug) shall be determined in accordance with:

$$Ug = Fd/D$$

Where

F = Source size, i.e. the maximum projected dimension of the radiating source (or focal spot) in the plane perpendicular to the distance D from the weld or object being radiographed.

D = distance from source of radiation to weld or object being radiographed.

d = distance from source side of weld or object being radiographed to the film.

Note: Refer to recommended practice ASME Sec. V-SE-94 for a method of determining geometric Un-sharpness. Alternatively Nomogram as shown in recommended practice ASME Sec. V–SE-94 may be used. Nomogram as shown in Fig. No. 7 of this procedure can also be used which are reproduction of ASME Sec V–SE-94.

8.6 Location Markers:

Location markers which are to appear as radiographic images on the film shall be placed on the part as per Fig.6 of this procedure and shall be placed as follows.

8.6.1 Single-Wall Viewing:

a) Source side markers

Location markers shall be placed on the source side when the radiography is performed on the following:

1. Flat components or longitudinal joints in cylindrical components;
2. Curved or spherical components whose concave side is towards the source and when the source- to- material distance is less than the inside radius of the component;
3. Curved or spherical components whose convex side is towards source.

b) Film Side Markers:

1. Location markers shall be placed on the film side when performing radiography of curved spherical components whose concave side is towards the source and when source to material distance is greater than the inside radius.
2. As an alternative to source side placement in 8.6.1 (a) 1, location markers may be placed on the film side when the radiograph shows coverage beyond the location markers to the extent demonstrated in Fig.6 sketch (e).

c) Either Side Markers:

Location markers may be placed on either the source side or film side when performing radiography on curved or spherical components whose concave side is toward the source and the source to material distance equals the inside radius of the component.

8.6.2 Double Wall Viewing:

When performing radiography with double wall viewing, at least one location marker shall be placed on the outside surface adjacent to the weld (on the material in the area of interest) for each radiograph.

8.6.3 Mapping the placement of location markers:

When inaccessibility or other limitation, prevent the placement of markers as stipulated in clauses 8.6.1 and 8.6.2, a dimensional map of the actual markers placement shall accompany the radiographs and shall show that full coverage has been obtained.

8.7 IQI Selection:

a) IQI shall be selected from either the same alloy group or grade as identified in ASME SE – 1025 (for hole type) and ASME SE – 747 (for wire type) or from an alloy material or grade with less radiation absorption than the material being radiographed.

b) The quality level required for radiography shall be at least 2% (2-2T) unless a higher or lower quality level is contractually agreed upon. The essential hole size and designated penetrameters shall be as specified in Table 1 as applicable. A smaller hole in a thicker penetrameter or a larger hole in a thinner penetrameter may be substituted for any section thickness listed in Table 1 provided equivalent penetrameter sensitivity (EPS) is maintained and all other requirements for radiography are met. EPS is to be calculated as specified in ASME SE – 1025. Refer Table 4 for equivalent hole type IQI sensitivity.

c) For welds made in accordance with ASME boiler and pressure vessel code Sec. III, penetrameter selection shall be based on Table 5 for class I ASME Sec. III (Sub Section NB) and class II (Sub Section NC) components.

d) Selection of penetrameters shall be made from Table 3 for radiographic examination for components fabricated in accordance with ASME Sec. III Sub section ND and ASME Sec. VIII. Div. 1.

e) For welds with reinforcement: The thickness on which the penetrameter is based is the nominal single wall thickness plus the reinforcement permitted by the referencing code. Backing rings or strips are not to be considered as part of the weld or reinforcement thickness in penetrameter selection.

f) Welds without reinforcement: When welds made without reinforcements, the penetrameter selection is based on nominal single wall thickness. Backing rings or strips are not to be considered as a part of the weld thickness in penetrameter selection.

8.7.1 Use of penetrameters to monitor radiographic examination

8.7.1.1 Placement of penetrameters:

a) Source side penetrameters(s):

The penetrameter (s) shall be placed on the source side of the part being radiographed, except as described in (b) below.

b) Film side penetrameter(s):

Where inaccessibility prevents hand placing of the penetrameter on the source side it shall be placed on the film side of the part under radiography and a lead letter “F” at least as high as identification number(s) shall be placed adjacent to or on the penetrameter(s). In no case the letter “F” shall mask the essential hole where hole penetrameters are used.

c) Penetrameter location for welds – Hole Penetrameter

The penetrameter(s) may be placed adjacent to or on the weld. The identification numbers and the letter "F", when used, shall not be in the area of interest. The identification numbers and lead letter "F" may be placed in the area of interest with the following exceptions;

1) When geometric configuration makes it impractical.

2) When the weld metal is not radiographically similar to the base material.

d) Penetrameter location for welds – Wire type Penetrameter

The penetrameters shall be placed on the weld in such a manner that the length of the wires is perpendicular to the length of the weld. The identification numbers and lead letter, when used shall not be in the area of interest, except for the conditions outlined in clause 8.7.1.1 (c) (1) or (2).

e) When performing radiography of welds, penetrameter(s) shall be placed on the parent material approximately 1/8 inch (3 mm) from the edge of the weld seam.

f) Alternative location for penetrameter(s):

When the configuration or size prohibits placing the penetrameter on the object being radiographed, the penetrameter may be placed on a separate block radiographically similar. The block shall be placed as close as possible to the material being radiographed.

In any case the position of the penetrameter shall not interfere with the interpretation of the area of interest shall be placed on the source side.

g) When examining double walled parts such as piping or duct, with source positioned outside the pipe, the penetrameter shall be placed, where practicable, on the outside of the pipe along side the weld.

h) Where placement of penetrameter on the source side is impracticable, use of film side penetrameter is permitted.

8.7.1.2 Number of Penetrameters:

a) Except as provided in 8.7.1.2 (c) one penetrameter shall be used for each radiograph. Each penetrameter shall represent an area of essentially uniform radiographic density as judged by a densitometer. If the density of the radiograph anywhere through the area of interest varies more than minus 15% or plus 30% from the density that adjacent to penetrameter then an additional penetrameter shall be used for each exceptional area or areas. In each case acceptable sensitivity shall be achieved.

b) For those sections where the thickness varies sufficiently to cause difficulty in meeting requirements of 9.2.1 with one penetrameter, two penetrameters shall be used representing the thinnest and the thickest section in the area of interest and the intervening densities on the radiograph shall be considered as having acceptable densities.

c) Special case:

1. For cylindrical vessels or flat products where one or more film holders/cassettes are used for a single exposure, a penetrameter image on each radiograph shall appear. Where the source is placed on the axis of the object and a complete circumference using one or more film holders/cassettes is radiographed with a single exposure at least three penetrameters approximately 120^0 apart shall be used.
2. Where sections of longitudinal welds adjoining the circumferential welds are radiographed simultaneously with the circumferential weld an additional penetrameter shall be placed on each longitudinal weld at the end of each section most remote from the junction with a circumferential weld being radiographed.
3. For cylindrical vessels where the source is placed on the axis of the object and four or more film holders are required to radiograph a single section of the circumference, at least three penetrameters shall be used. One penetrameter shall be placed approximately in the centre of the section exposed and one at each end. Otherwise at least one penetrameter image shall appear on each radiograph when the section of the circumference exposed exceeds 240^0; rules of (1) and (2) shall apply.
4. For spherical vessels where the source is located at the centre of the vessel and one or more film holders are exposed for a complete circumference a minimum of three penetrameters shall be spaced approx 120^0 apart. For other welds, radiographed simultaneously, one additional penetrameter shall be placed on each other weld.
5. When segments of spherical vessel are radiographed in a single exposure, source located at the centre of the vessel using four or more film holders for an exposure of circumferential weld, at least three penetrameters shall be used to keeping one penetrameter in the approximate centre of the portion exposed and one at each end. When the portion exposed exceeds 240^0; the rules of (4) above apply. In each case additional film locations may be required to establish proper penetrameter spacing, otherwise at least one penetrameter image shall appeared on each radiograph.
6. When an array of objects in a circle is radiographed at least one penetrameter shall show on each object image.

8.7.1.3 Shims under hole penetrameters:

a) A shim of material radiographically similar to the weld metal shall be placed under the penetrameter in case weld reinforcement and or backing strip/rings are not removed.

b) The thickness of shim used should be at least equal to thickness of backing ring plus thickness of weld reinforcement allowed.) The shim dimensions shall exceed the penetrameter dimensions by at least 1/8 inch (3 mm) on all sides. The shimmed

penetrameter shall not overlap the backing strip or ring. The outline of at least three sides of the penetrameter images shall be visible in the radiograph.

c) Where shims are used under the penetrameter the radiographic density throughout the area of interest shall not more than minus 15% from (lighter than) the radiographic density through the penetrameter throughout the area of interest.

8.8 Time of Examination:

8.8.1 Radiographic examination of welds shall be performed after intermediate or final heat treatment, when required except as below,

8.8.2 For ASME-Sec III NB

a) Radiographic examination of welds in piping, pumps and valves fabricated of P.No. 1 material may be performed prior to any required PWHT.

b) Radiographic examination of welds in vessels fabricated of P.No.1 materials and all welds in components fabricated of P.No.3 materials may be performed prior to an intermediate or final (PWHT) provided the welds are ultrasonically examined after an intermediate or final Post Weld Heat Treatment.

8.8.3 For ASME-Sec III NC & ND

a) Radiographic examination of welds in items fabricated of P.No.1 materials may be performed prior to any required post weld heat treatment.

b) Radiographic examination of welds in P.No.3 materials may be performed prior to an intermediate or final (PWHT) provided the welds are ultrasonically examined after an intermediate or final Post Weld Heat Treatment.

Note: An intermediate PWHT for examination is defined as a PWHT on a weld within a temperature range to which the weld shall be subjected during the final PWHT.

9.0 EVALUATION

9.1 Quality of radiograph:

a) All the radiographs shall be free from chemical, mechanical handling related or other blemishes which could interfere with proper interpretation of the radiograph.

b) Each radiograph shall be examined for processing defects and shall be considered not interpretable when one or combination of the following defects are seen on radiograph:

- fogging
- processing defects such as streaks, water marks
- damage to emulsion, scratches, crimps, static marks
- discoloration due to improper fixing or washing
- loss of detail due to poor screen to film contact
- strain marks

9.2 Radiographic Density:

9.2.1 Density limitation:

The transmitted film density through the radiographic image of the body of the appropriate penetrameter and the area of interest shall be 1.8 minimum for single film viewing for radiographs made with an X-Ray source and 2.0 minimum for radiographs made with a gamma ray source. For composite viewing of multiple film exposures, each film of composite set shall have a minimum density of 1.3. The maximum density shall be 4.0 for either single or composite viewing. A tolerance of 0.05 in density is allowed for variations between densitometer readings.

9.2.2 Density Variation:

c) **General –** If the density of the radiograph anywhere through the area of interest varies by more than minus 15% or plus 30% from the density through the body of the whole penetrameter or adjacent to designated wire of a wire type penetrameter, within minimum/maximum allowable density range is specified in 9.2.1, then an additional penetrameter shall be used for each exceptional area or areas and the radiograph retaken. The allowable variation in density may be rounded to the nearest 0.1 within the range specified in 9.2.1.

d) **With Shims –** When shims are used the plus 30% density restriction of 9.2.2 (a) may be exceeded, provided the required penetrameter sensitivity is displayed and the density limitations of 9.2.1 are not exceeded.

9.3 Image Quality Indicators (Penetrameters) Sensitivity:

Radiography shall be performed with a technique of sufficient sensitivity to display the penetrameter image and the specified hole of plate type penetrameter or required wire of wire type penetrameter. The images of the identifying numbers, penetrameters image and specified hole are essential indications of the image quality and shall appear on the radiograph. As far as possible the penetrameter shall be placed perpendicular to the radiation beam, if the required penetrameter image and specified hole do not show on any film in a multiple film technique but do show in composite film viewing, interpretation shall be permitted only by composite film viewing.

9.4 Excessive Scatter:

If the image of symbol “B” specified in clause 5.3 appears on the radiograph as a lighter density than background, it is an indication that the protection from back scatter is insufficient and the radiograph shall be considered unacceptable. A dark image of the symbol “B” on a lighter background is not a cause for rejection.

9.5 Geometric Un-sharpness Limitation :

Geometric Un-sharpness (Ug) determined as per clause 8.5 of this procedure shall be within following limits:

Material Thickness inch (mm)	Ug maximum inch (mm)
Under 2 (50)	0.020 (0.51)
2 through 3 (50-75)	0.030 (0.76)
Over 3 through 4 (75-100)	0.040 (1.02)
Greater than 4 (100)	0.070 (1.78)

Note: Material thickness is the thickness on which the penetrameter is based.

10.0 INTERPRETATION:

All the final radiographs shall be submitted to the purchaser or his authorized representative for evaluation and acceptance. The radiographs shall be evaluated and interpreted by the manufacturer's Level II or Level III qualified personnel prior to offering for interpretation to Quality Assurance Engineers of NPCIL. The interpreted results of each radiograph and disposition of material examined shall be recorded by the manufacturer in the examination report and the same shall be available with the radiographs at the time of evaluation and interpretation by NPCIL.

Discontinuities revealed in welds shall be interpreted to the appropriate degree of defects in accordance with the norms of acceptance laid down in Para 12 of this procedure. **However final acceptance criteria shall be governed by the controlling product Specification, Purchase Order or Drawing.**

11.0 DOCUMENTATION:

11.1 Examination report:

To aid in proper interpretation of radiography and to have a final status of acceptance of radiographs, examination reports shall be prepared for each group of radiographs and submitted for approval/acceptance.

The examination report shall at least include the following information: and the same shall be filled.

a) Manufacturer Name, Job Number.

b) Identification of part and weld seam.

c) Identification of welder

d) Thickness of radiographed area, diameter/size of the job.

e) Material type and grade.

f) Applicable specification.

g) Type and size of source (Isotope or max. X-Ray voltage used)

h) Type of films and type of processing used.

i) No. of films per cassette.

j) Type, number and thickness of screen and filters used.

k) No. of exposures.

l) Exposure time.

m) Single wall and double wall exposure and viewing.

n) Type and designation of IQI and required sensitivity.

o) Film density achieved.

p) Sensitivity achieved.

q) Interpretation of film results.

r) Remarks for unusual occurrences.

s) Date of examination and signature of evaluator.

t) Qualification level of operator and personnel performing evaluation.

11.2 Storage of Processed Radiographs:

The radiographs should be stored in such a manner that staining and fading of image is prevented. The films should be protected from excessive heat and humidity. The envelopes sealed at an edge with non-hygroscopic adhesive shall be stored in a safe place. For storage of films, detailed instructions of the film manufacturer shall be followed. The system of storage shall be so organized that when required, the radiograph of a pertinent joint of required component can be easily withdrawn for reference.

11.3 Retention period of processed radiographs:

a) Life time records:

Final radiographs pertaining to ASME-Sec. III NB & NC components identified for INSERVICE INSPECTION and INSERVICE TESTING shall be classified as life time records and shall be retained by NPCIL for the service life time of the component or system. The radiographs shall be properly identified, packed and submitted to NPCIL by manufacturer.

b) Non – permanent records:

Final radiographs of ASME – Sec. III NB and NC components which are not identified for INSERVICE INSPECTION and INSERVICE TESTING shall be classified as non-permanent records. Unless otherwise specified by job order or contract, the manufacturer shall be responsible to retain final radiographs of components manufactured in accordance with ASME – Sec. III NB & NC & ND for a period of 10 years.

11.4 Digitalization of Radiographs:

Radiographs shall be digitalized in accordance with ASME Sec V Article 2 Mandatory Appendix VI, if so required by the product specification or Purchase Order/Contract.

12.0 RADIOGRAPHIC ACCEPTANCE STANDARD:

12.1 Full Radiography:

Acceptance standard for welds in accordance with ASME code, Sec. III Class 1, class 2 and class 3 components and ASME. SEC. VIII DIVISION 1 components for full radiography shall be as given below:

12.1.1 Following type of indications that are shown on radiographs of welds and characterized as imperfections are unacceptable.

a) Any type of cracks or a zone of incomplete fusion or penetration.

b) Any other elongated indication which has a length greater than:

i) 1/4 inch (6 mm) for t up to 3/4 inch (19 mm) inclusive.

ii) 1/3 t for t from 3/4 inch to 2 1/4 inch (19 mm – 57 mm) inclusive

iii) 3/4 inch (19 mm) for t over 2 1/4 inch (57 mm)

Where "t" is thickness of thinner portion of weld.

c) Internal root weld conditions are acceptable when the density change as indicated in the radiograph is not abrupt; elongated indications on the radiograph at either edge of such conditions shall be unacceptable, as provided in 12.1.1 (b) above.

d) Any group of aligned indications having an aggregate length greater than t in a length of 12 t unless the minimum distance between successive indications exceeds 6L, in which case the aggregate length is unlimited, L being the length of the largest indication.

e) Rounded indications in excess of that shown as acceptable as per clause number 12.4 of this procedure.

12.2 Acceptance standard for spot radiography examination for ASME Sec. III – ND and ASME Sec. VIII Div. I components:

12.2.1 Butt welded joints which are to be spot radiographed shall be judged by the following acceptance standards.

a. Welds in which the radiograph shows any type of cracks or zone of incomplete fusion or penetration shall be unacceptable.

b. Welds in which the radiographs show slag inclusions or cavities shall be unacceptable if the length of any such imperfection is greater than 2/3 t where t is the thickness of the thinner material welded. For all thicknesses, indications less than 6 mm are acceptable and indications greater than 19mm are unacceptable. If several imperfections within the above limitations exist in line, the weld shall be judged

acceptable if the some of the longest dimensions of all such imperfections is not more than t in a length of 6t (or proportionately for radiograph shorter than 6t) and if the longest imperfections considered or separated by at least 3L of acceptable weld metal, where L is the length of the longest imperfection.

c. Rounded indications are not a factor in the acceptability of welds not required to be fully radiographed.

12.3 Acceptance Standard for Component Supports- ASME Sec. III subsection NF:

Acceptance criteria of weld joints shall be as per para 12.1.1 (a) to 12.1.1 (d). Rounded indications are not a factor in the acceptability of welds that are radiographed.

12.4 A Standards for Radiographically Determined Rounded Indication in Welds (as per ASME Sec- VIII Div 1 Mandatory appendix 4)

12.4.1 Terminology:

a) Rounded indication:

Indications with a maximum length of three times of width or less on the radiograph are defined as rounded indications. These indications may be circular, elliptical, conical or irregular in shape and may have tails. When evaluating the size of an indication the tail shall be included. The indication may be from any source in the weld, such as porosity, slag and tungsten.

b) Aligned indications:

A sequence of four or more rounded indications shall be considered to be aligned when they touch a line parallel to the length of the weld drawn through the centre of two outer rounded indications.

c) Thickness "**t":**

"t" is the thickness of the weld, excluding any allowable reinforcement of the pressure retaining material, or of thinner of the two if members with different sections being joined. If a full penetration weld includes a fillet weld, the thickness of the fillet weld throat shall be included in "t".

12.4.2 Acceptance criteria

a) Image density**:**

Density within the image of indication may vary and is not a criterion for acceptance or rejection.

b) Relevant indications (Refer Table-6):

Only those rounded indications which exceed the following dimensions shall be considered relevant:

1/10 t for t less than 1/8 inch (3 mm)

1/64 inch (0.4 mm) for t equal to 1/8 – 1/4 inch (3 – 6 mm) inclusive

1/32 inch (0.8 mm) for t greater than 1/4-2 inch (6 – 50 mm) inclusive

1/16 inch (1.5 mm) for t greater than 2 inch (50 mm)

c) Maximum size of rounded indication (Refer Table-6):

The maximum permissible size of any indication shall be 1/4 t or 5/32 inch (4 mm) whichever is less; except that an isolated indication separated from an adjacent indication by 1 inch (25 mm) or more may be 1/3 t or 1/4 inch (6 mm) whichever is less. For t greater than 2 inch (50 mm) the maximum permissible size of an isolated indication shall be increased 3/8 inch (10 mm)

d) Aligned rounded indications:

Aligned rounded indications are acceptable when the summation of the diameters of the indications is less than t in a length of 12t (Fig.8.1). The length of groups of aligned rounded indications and the spacing between the groups shall meet the requirements of Fig. 8.2.

e) Spacing:

The distance between adjacent rounded indications is not a factor in determining acceptance or rejection, except as required for isolated indications or groups of aligned indications.

f) Rounded indication charts:

(Ref Fig. 8.3 to 8.8, these figs. as attached in this procedure are for illustration only, for actual size APPENDIX 4 of ASME Sec VIII Div 1 is to be referred).

1. The rounded indications as determined from the radiographic film shall not exceed that shown in the charts.
2. The charts illustrate various types of assorted, randomly dispersed and clustered rounded indication for different weld thickness greater than 1/8 inch (3mm). These charts represent the maximum acceptable concentration limits for rounded indications.
3. The chart for each thickness range represents full-scale 6 inch (150 mm) radiographs and shall not be enlarged or reduced. The distributions shown are not necessarily the patterns that may appear on the radiograph, but are typical of the concentration and size of indications permitted.

g) Weld thickness "t" less than 1/8 in (3 mm):

For t less than 1/8 inch (3 mm) the maximum number of rounded indications shall not exceed 12 numbers in a 6 inch (150 mm) length of weld. A proportionally fewer number of indications shall be permitted in welds less than 6 inch (150 mm) in length.

h) Clustered indications:

The illustrations for clustered indications show up to four times as many indications in a local area as that shown in the illustrations for random indications. The length of an acceptable cluster shall not exceed the lesser of 1 inch (25 mm) or 2 t. Where more than one cluster is present, the sum of the lengths of the cluster shall not exceed 1 inch (25 mm) in a 6 inch (150 mm) length of weld.

TABLE – 1

(Reference: TABLE T-233.1 ASME Sec, V Article 2)

HOLE – TYPE IQI DESIGNATION, THICKNESS, AND HOLE DIAMETERS

IQI Designation	IQI Thickness, T inch (mm)	1T Hole Diameter, inch (mm)	2T Hole Diameter, inch (mm)	4T Hole Diameter, inch (mm)
5	0.005 (0.13)	0.010 (0.25)	0.020 (0.51)	0.040 (1.02)
7	0.0075 (0.19)	0.010 (0.25)	0.020 (0.51)	0.040 (1.02)
10	0.10 (0.25)	0.010 (0.25)	0.020 (0.51)	0.040 (1.02)
12	0.0125 (0.32)	0.0125 (0.32)	0.025 (0.64)	0.050 (1.27)
15	0.015 (0.38)	0.015 (0.38)	0.030 (0.76)	0.060 (1.52)
17	0.0175 (0.44)	0.0175 (0.44)	0.035 (0.89)	0.070 (1.78)
20	0.020 (0.51)	0.020 (0.51)	0.040 (1.02)	0.080 (2.03)
25	0.025 (0.64)	0.025 (0.64)	0.050 (1.27)	0.100 (2.54)
30	0.030 (0.76)	0.030 (0.76)	0.060 (1.52)	0.120 (3.05)
35	0.035 (0.89)	0.035 (0.89)	0.070 (1.78)	0.140 (3.56)
40	0.040 (1.02)	0.040 (1.02)	0.080 (2.03)	0.160 (4.06)
45	0.045 (1.14)	0.045 (1.14)	0.090 (2.29)	0.180 (4.57)
50	0.050 (1.27)	0.050 (1.27)	0.100 (2.54)	0.200 (5.08)
60	0.060 (1.52)	0.060 (1.52)	0.120 (3.05)	0.240 (6.10)
70	0.070 (1.78)	0.070 (1.78)	0.140 (3.56)	0.280 (7.11)
80	0.080 (2.03)	0.080 (2.03)	0.160 (4.06)	0.320 (8.16)
100	0.100 (2.54)	0.100 (2.54)	0.200 (5.08)	0.400 (10.16)
120	0.120 (3.05)	0.120 (3.05)	0.240 (6.10)	0.480 (12.19)
140	0.140 (3.56)	0.140 (3.56)	0.280 (7.11)	0.560 (14.22)
160	0.160 (4.06)	0.160 (4.06)	0.320 (8.13)	0.640 (16.26)
200	0.200 (5.08)	0.200 (5.08)	0.400 (10.16)	-
240	0.240 (6.10)	0.240 (6.10)	0.480 (12.19)	-
280	0.280 (7.11)	0.280 (7.11)	0.560 (14.22)	-

TABLE -2

WIRE – TYPE IQI DESIGNATION, AND DIAMETERS
(Ref: Table T-233.2, ASME Sec V, Article2)

Table T-233.2
Wire IQI Designation, Wire Diameter, and Wire Identity

Set A			Set B		
Wire Diameter, in.	(mm)	Wire Identity	Wire Diameter, in.	(mm)	Wire Identity
0.0032	(0.08)	1	0.010	(0.25)	6
0.004	(0.10)	2	0.013	(0.33)	7
0.005	(0.13)	3	0.016	(0.41)	8
0.0063	(0.16)	4	0.020	(0.51)	9
0.008	(0.20)	5	0.025	(0.64)	10
0.010	(0.25)	6	0.032	(0.81)	11
Set C			**Set D**		
Wire Diameter, in.	(mm)	Wire Identity	Wire Diameter, in.	(mm)	Wire Identity
0.032	(0.81)	11	0.100	(2.54)	16
0.040	(1.02)	12	0.126	(3.20)	17
0.050	(1.27)	13	0.160	(4.06)	18
0.063	(1.60)	14	0.200	(5.08)	19
0.080	(2.03)	15	0.250	(6.35)	20
0.100	(2.54)	16	0.320	(8.13)	21

TABLE -3

(Reference: TABLE T - 276 of ASME Sec, V Article 2)

IQI SELECTION

Nominal Single Wall material Thickness Range		IQI			
		Source Side		Film Side	
inch	mm	Hole type Designation	Wire-Type Essential Wire	Hole type Designation	Wire-Type Essential Wire
Up to 0.25, incl.	Up to 6.4, incl.	12	5	10	4
Over 0.25 through 0.375	Over 6.4 through 9.5	15	6	12	5
Over 0.375 through 0.50	Over 9.5 through 12.7	17	7	15	6
Over 0.50 through 0.75	Over 12.7 through 19.0	20	8	17	7
Over 0.75 through 1.00	Over 19.0 through 25.4	25	9	20	8
Over 1.00 through 1.50	Over 25.4 through 38.1	30	10	25	9
Over 1.50 through 2.00	Over 38.1 through 50.8	35	11	30	10
Over 2.00 through 2.50	Over 50.8 through 63.5	40	12	35	11
Over 2.500 through 4.00	Over 63.5 through 101.6	50	13	40	12
Over 4.00 through 6.00	Over 101.6 through 152.4	60	14	50	13
Over 6.00 through 8.00	Over 152.4 through 203.2	80	16	60	14
Over 8.00 through 10.00	Over 203.2 through 254.0	100	17	80	16
Over 10.00 through 12.00	Over 254.0 through 304.8	120	18	100	17
Over 12.00 through 16.00	Over 304.8 through 406.4	160	20	120	18
Over 16.00 through 20.00	Over 406.4 through 508.0	200	21	160	20

Note:

For Hole type IQI essential hole is 2T for above table, where T is thickness of penetrameter.

TABLE -4

(Reference: ASME Sec V Article 2)

Table T-283
Equivalent Hole-Type IQI Sensitivity

Hole-Type Designation	Equivalent Hole-Type Designations	
2*T* Hole	1*T* Hole	4*T* Hole
10	15	5
12	17	7
15	20	10
17	25	12
20	30	15
25	35	17
30	40	20
35	50	25
40	60	30
50	70	35
60	80	40
80	120	60
100	140	70
120	160	80
160	240	120
200	280	140

TABLE -5

(Reference: TABLE NB-5111-1 of ASME Sec, III div 1 - NB)

THICKNESS PENETRAMETER DESIGNATION AND ESSENTIAL HOLES AND WIRE DIAMETERS

Single Wall material Thickness Range, inch(mm)	Penetrameters – Hole or Wire Type							
	Source Side				Film Side			
	Designation	Hole Size inch(mm)	Essential Hole	Required wire dia-IQI, inch (mm)	Designation	Hole Size inch(mm)	Essential Hole	Required wire dia-IQI, inch(mm)
Upto 0.25 (6) incl.	5	0.040 (1.02)	4T	0.006 (0.15)	5	0.040 (1.02)	4T	0.006 (0.15)
Over ¼-3/8 (6-10)	7	0.040 (1.02)	4T	0.006 (0.15)	7	0.040 (1.02)	4T	0.006 (0.15)
Over 3/8-1/2 (10-13)	10	0.040 (1.02)	4T	0.010 (0.25)	10	0.040 (1.02)	4T	0.010 (0.25)
Over ½-5/8 (13-16)	12	0.050 (1.27)	4T	0.013 (0.33)	12	0.050 (1.27)	4T	0.013 (0.33)
Over 5/8-3/4 (16-19)	15	0.060 (1.52)	4T	0.016 (0.41)	12	0.050 (1.27)	4T	0.013 (0.33)
Over ¾-1 (19-25)	20	0.040 (1.02)	2T	0.016 (0.41)	17	0.035 (0.89)	2T	0.013 (0.33)
Over 1-1.25 (25-32)	25	0.050 (1.27)	2T	0.020 (0.51)	17	0.035 (0.89)	2T	0.013 (0.33)
Over 1.25-1.5 (32-38)	30	0.060 (1.52)	2T	0.025 (0.64)	20	0.040 (1.02)	2T	0.016 (0.41)
Over 1.5-2 (38-50)	35	0.070 (1.78)	2T	0.032 (0.81)	25	0.050 (1.27)	2T	0.020 (0.51)
Over 2-2.5 (50-64)	40	0.080 (2.03)	2T	0.040 (1.02)	30	0.060 (1.52)	2T	0.025 (0.64)
Over 2.5-3 (64-75)	45	0.090 (2.29)	2T	0.040 (1.02)	35	0.070 (1.78)	2T	0.032 (0.81)
Over 3-4 (75-100)	50	0.100 (2.54)	2T	0.050 (1.27)	40	0.080 (2.03)	2T	0.040 (1.02)
Over 4-6 (100-150)	60	0.120 (3.05)	2T	0.063 (1.60)	45	0.090 (2.29)	2T	0.040 (1.02)
Over 6-8 (150-200)	80	0.160 (4.06)	2T	0.100 (2.54)	50	0.100 (2.54)	2T	0.050 (1.27)
Over 8-10 (200-250)	100	0.200 (5.08)	2T	0.126 (3.20)	60	0.120 (3.05)	2T	0.063 (1.60)
Over 10-12 (250-300)	120	0.240 (6.10)	2T	0.160 (4.06)	80	0.160 (4.06)	2T	0.100 (2.54)
Over 12-16 (300-400	160	0.320 (8.13)	2T	0.250 (6.35)	100	0.200 (5.08)	2T	0.126 (3.20)
Over 16-20 (400-500)	200	0.400 (10.16)	2T	0.320 (8.13)	120	0.240 (6.10)	2T	0.160 (4.06)

Note: In above table T is thickness of penetrameter.

TABLE –6

(Reference: TABLE VI-1132-1 of Mandatory Appendix VI, Article VI – 1000 of ASME Sec III Div 1 - Appendices and TABLE 4-1 of Appendix 4 of ASME Sec VIII Div 1)

MAXIMUM SIZE OF NON RELEVANT INDICATIONS AND ACCEPTABLE ROUNDED INDICATIONS - EXAMPLES ONLY

Thickness t, inch (mm)	Maximum size of Rounded Indication , inch (mm)		Maximum Size of Nonrelevent Indication, inch (mm)
	Random	Isolated	
< 1/8 (<3)	¼ t	1/3 t	1/10 t
1/8 (3)	0.031 (0.8)	0.042 (1.1)	0.015 (0.4)
3/16 (5)	0.047 (1.2)	0.063 (1.6)	0.015 (0.4)
1/4 (6)	0.063 (1.6)	0.083 (2.1)	0.015 (0.4)
5/16 (8)	0.078 (2.0)	0.104 (2.6)	0.031 (0.8)
3 /8 (10)	0.091 (2.3)	0.125 (3.2)	0.031 (0.8)
7/16 (11)	0.109 (2.8)	0.146 (3.7)	0.031 (0.8)
1/2 (13)	0.125 (3.2)	0.168 (4.3)	0.031 (0.8)
9/16 (14)	0.142 (3.6)	0.188 (4.8)	0.031 (0.8)
5/8 (16)	0.156 (4.0)	0.210 (5.3)	0.031 (0.8)
11/16 (17)	0.156 (4.0)	0.230 (5.8)	0.031 (0.8)
3/4 - 2, incl (19-50 incl)	0.156 (4.0)	0.250 (6.4)	0.031 (0.8)
>2 (>50)	0.156 (4.0)	0.375 (9.5)	0.063 (1.6)

Fig.1

Single-Wall Radiographic Techniques

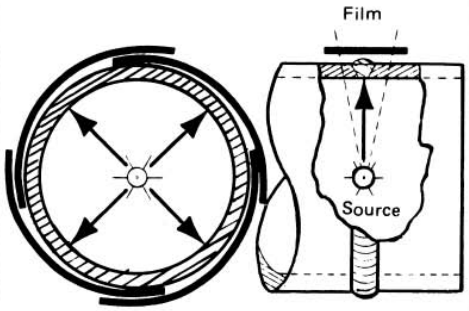
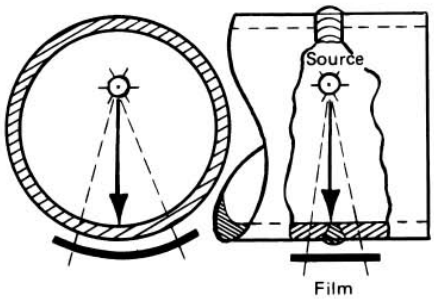
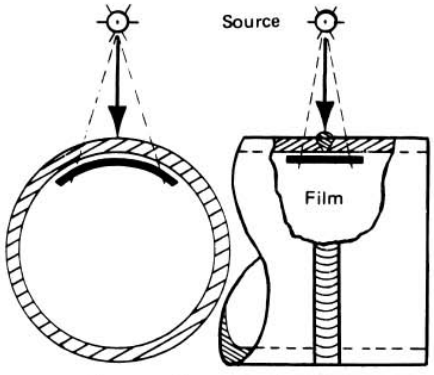
Pipe O.D.	Exposure Technique	Radiograph Viewing	Source-Weld-Film Arrangement		IQI		Location Marker Placement
			End View	Side View	Selection	Placement	
Any	Single-Wall T-271.1	Single-Wall	 Exposure Arrangement — A		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Either Side T-275.3 T-275.1(c)
Any	Single-Wall T-271.1	Single-Wall	 Exposure Arrangement — B		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Film Side T-275.1 (b)(1)
Any	Single-Wall T-271.1	Single-Wall	 Exposure Arrangement — C		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Source Side T-275.1 (a)(3)

Fig.2

Double-Wall Radiographic Techniques

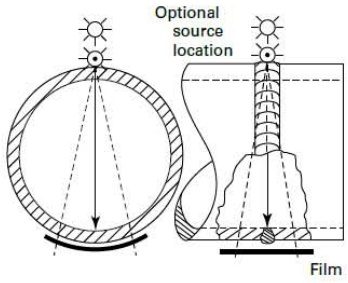
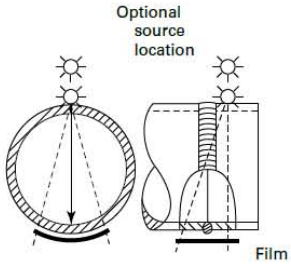
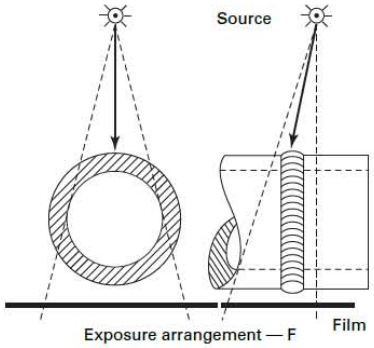
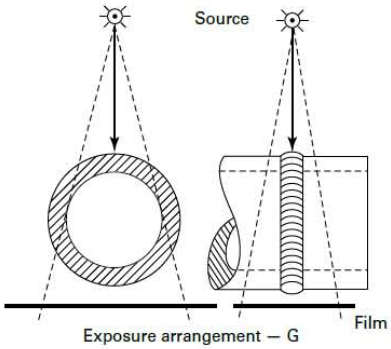
O.D.	Exposure Technique	Radiograph Viewing	Source-Weld-Film Arrangement (End View / Side View)	IQI: Selection	IQI: Placement	Location Marker Placement
Any	Double- Wall: T-271.2(a) at Least 3 Exposures 120 deg to Each Other for Complete Coverage	Single-Wall	 Exposure arrangement — D	T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Film Side T-275.1(b) (1)
Any	Double- Wall: T-271.2(a) at least 3 Exposures 120 deg to Each Other for Complete Coverage	Single-Wall	 Exposure arrangement — E	T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Film Side T-275.1(b) (1)
3½ in. (88 mm) or Less	Double-Wall T-271.2(b)(1) at Least 2 Exposures at 90 deg to Each Other for Complete Coverage	Double-Wall (Ellipse): Read Offset Source Side and Film Side Images	 Exposure arrangement — F	T-276 and Table T-276	Source Side T-277.1(a)	Either Side T-275.2
3½ in. (88 mm) or Less	Double-Wall: T-271.2(b)(2) at Least 3 Exposures at 60 deg or 120 deg to Each Other for Complete Coverage	Double-Wall: Read Super-imposed Source Side and Film Side Images	 Exposure arrangement — G	T-276 and Table T-276	Source Side T-277.1(a)	Either Side T-275.2

Fig.3

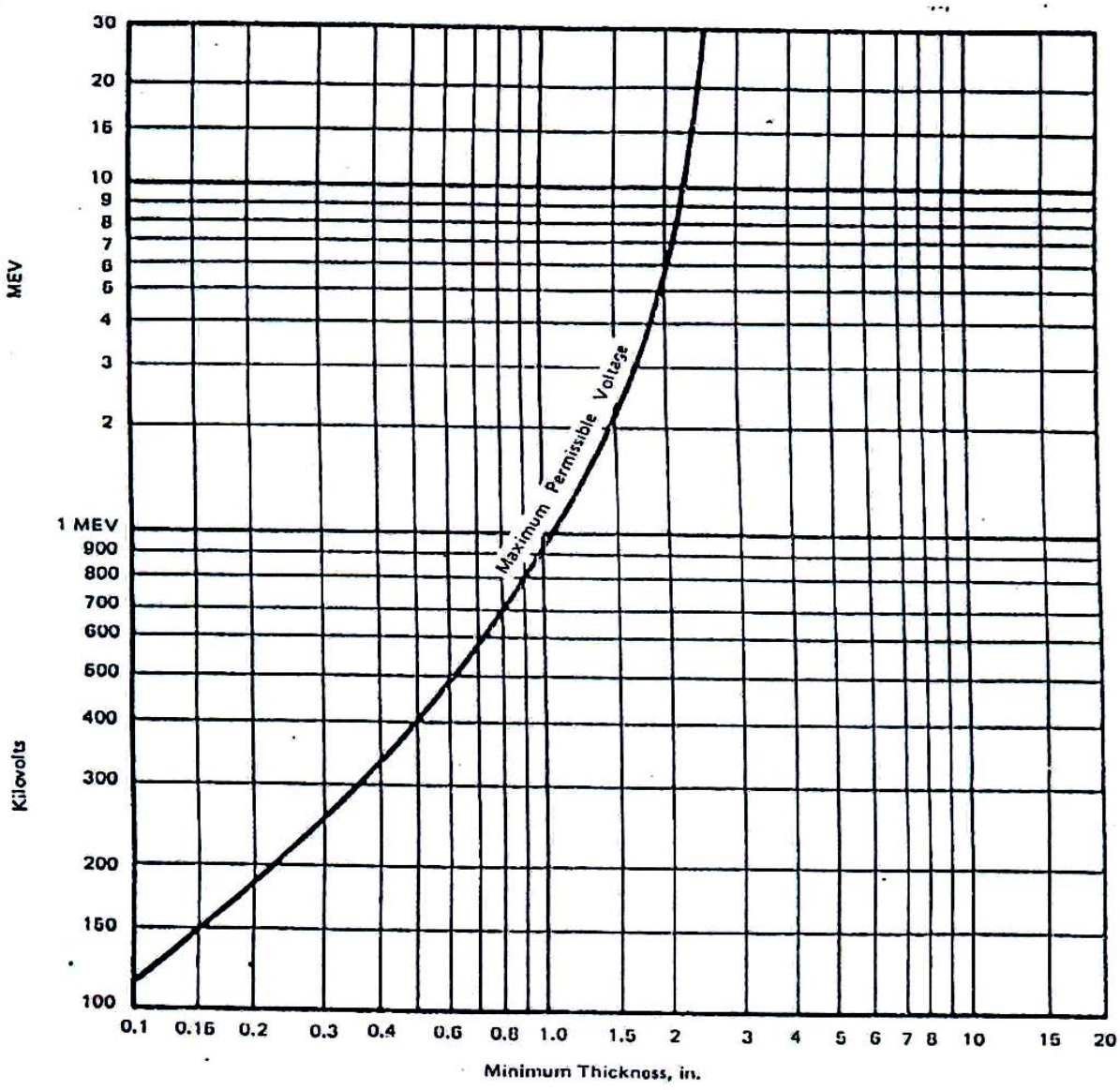


FIG. 3 MAXIMUM VOLTAGE FOR STEEL

Fig.4

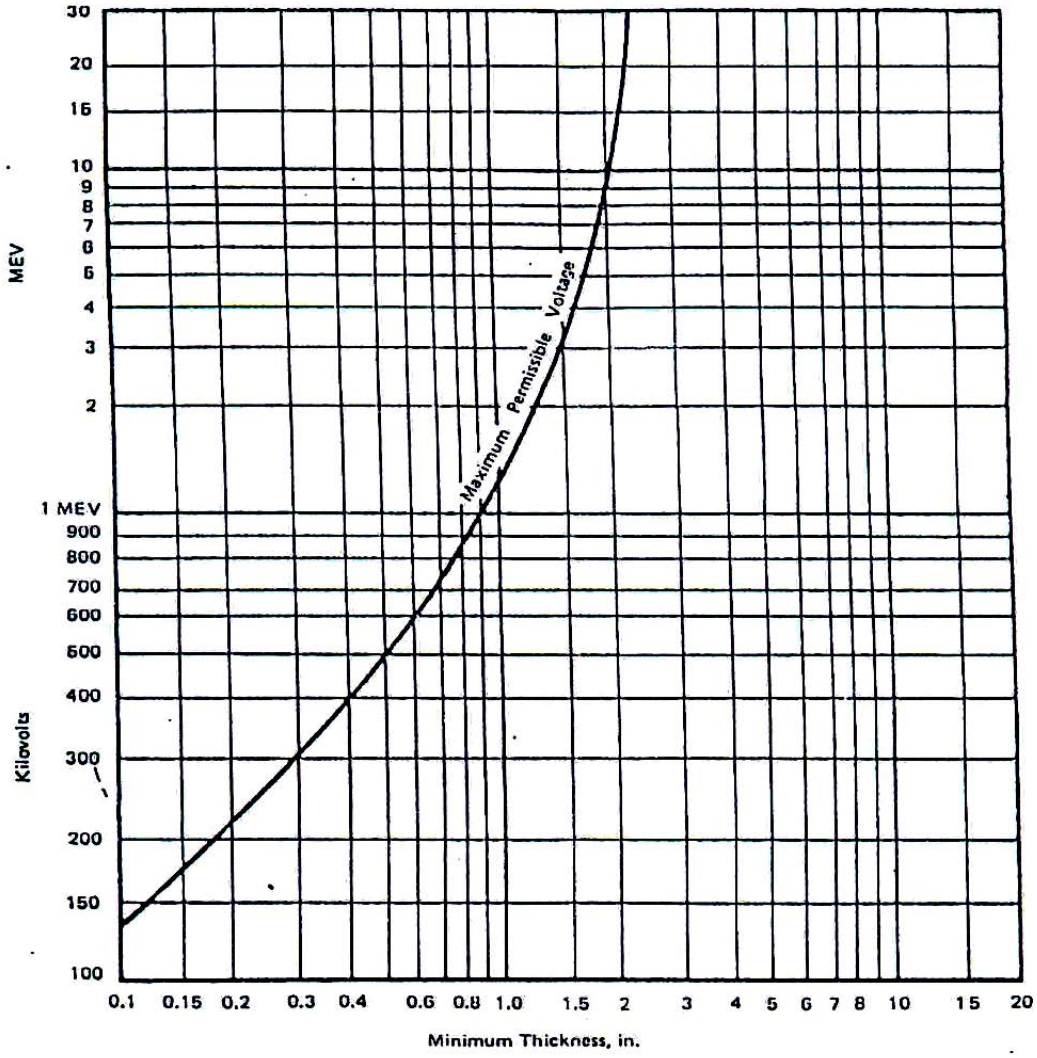


FIG. 4 MAXIMUM VOLTAGE OF ALLOYS FOR COPPER AND/OR HIGH NICKEL

Fig.5

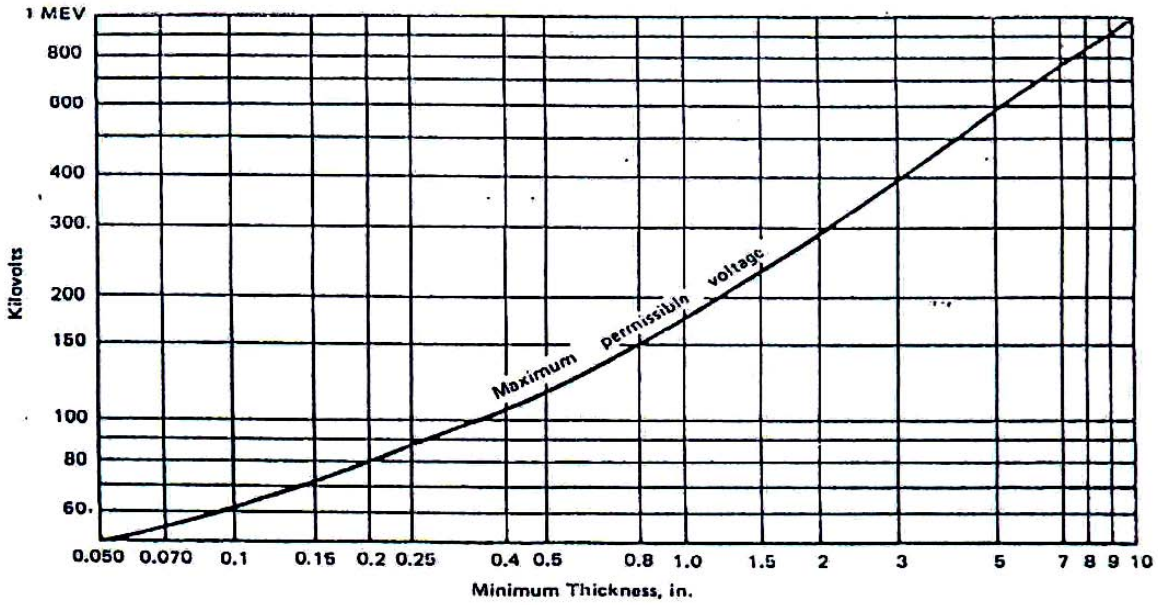


FIG. 5 MAXIMUM VOLTAGE PERMITTED FOR ALUMINUM AND ALUMINUM ALLOYS

Fig.6

Location Marker Sketches
(Ref: Fig. T-275 of ASME Sec V Article 2)

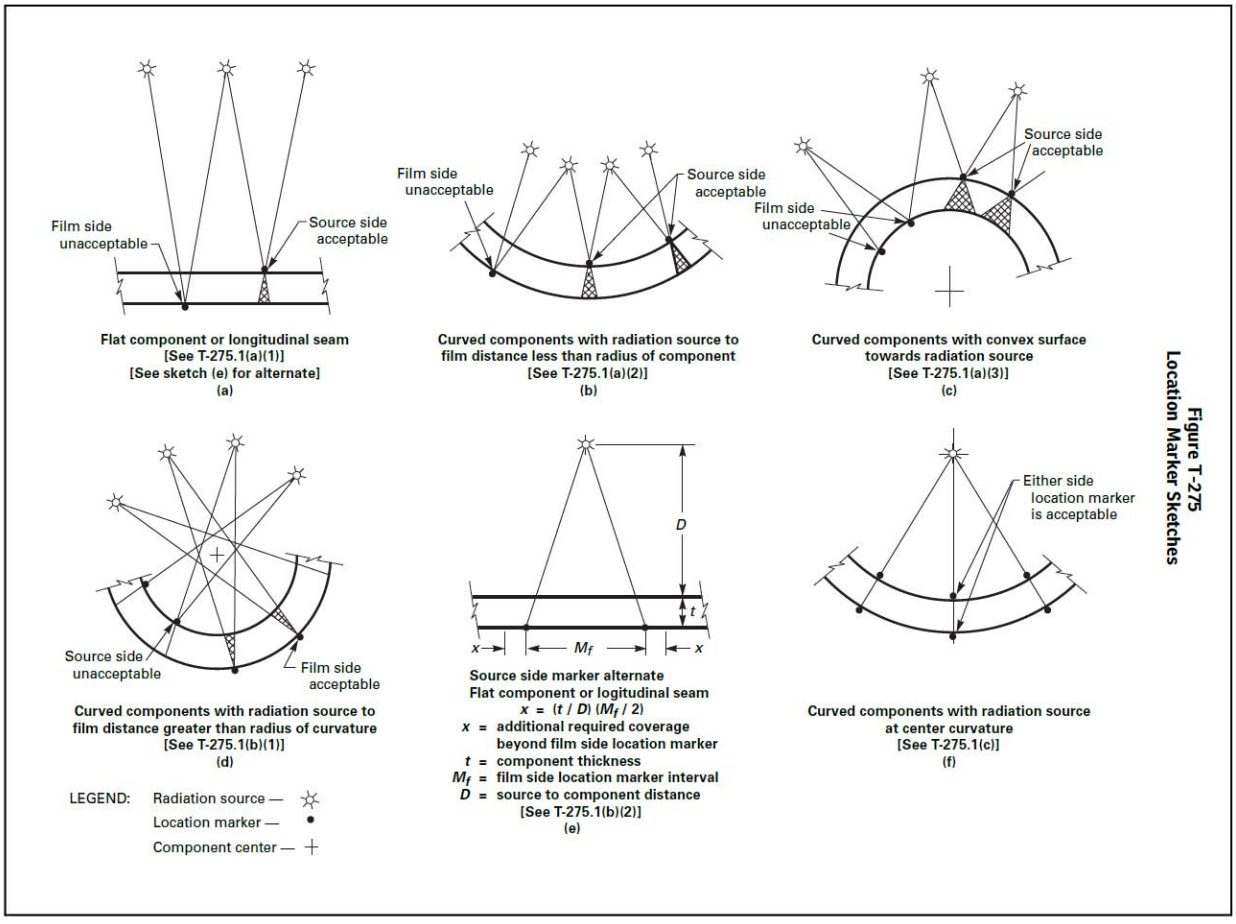
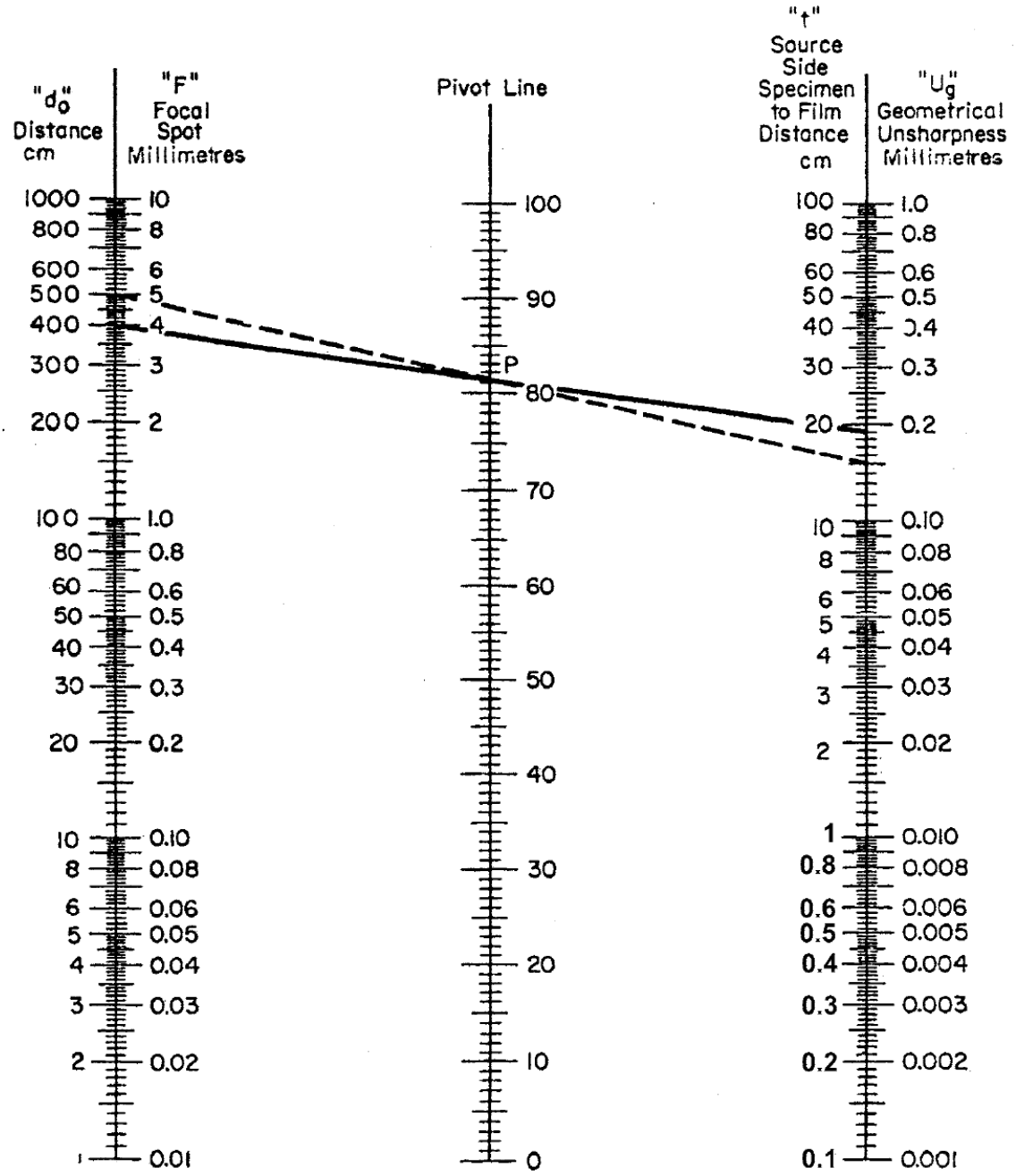


Fig.7

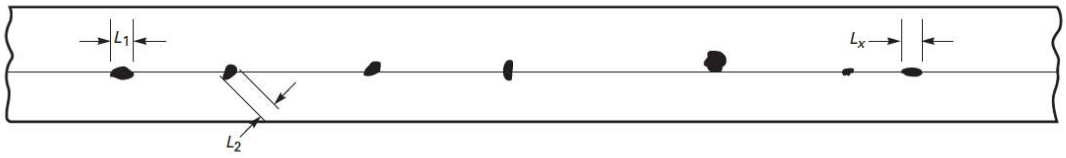
Nomogram for detecting Geometrical Unsharpness (Metric Units)
Ref: Fig.4 of ASME Sec.V Article 22 SE 94



Figures of Radiographically DeterminedAccepted Rounded indicationsin welds
(Ref: ASME Sec VIII Div I Mandetory Appendix 4; Fig.4-1 to 4-8)

Fig 8-1

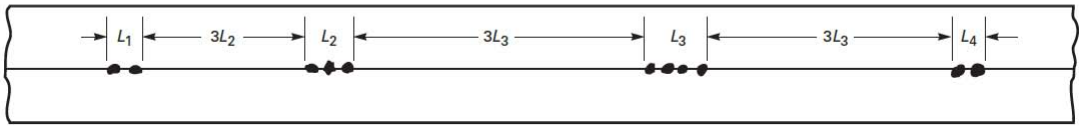
Aligned Rounded Indications



GENERAL NOTE: Sum of L_1 to L_x shall be less than t in a length of $12t$.

Fig 8-2

Groups of Aligned Rounded Indications

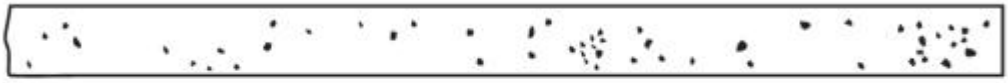


Maximum Group Length	Minimum Group Spacing
L = $1/4$ in. (6 mm) for t less than $3/4$ in. (19 mm) L = $1/3t$ for t $3/4$ in. (19 mm) to $2\,1/4$ in. (57 mm) L = $3/4$ in. (19 mm) for t greater than $2\,1/4$ in. (57 mm)	$3L$ where L is the length of the longest adjacent group being evaluated

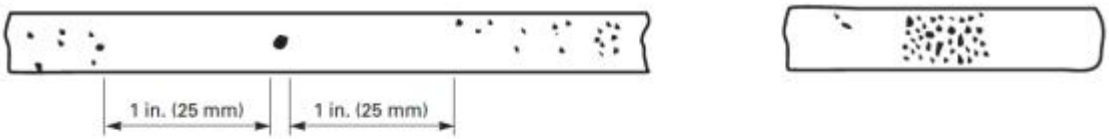
GENERAL NOTE: Sum of the group lengths shall be less than t in a length of $12t$.

Fig 8-3

Charts for *t* Equal to 1/8 in. to 1/4 in. (3 mm to 6 mm), Inclusive



(a) Random Rounded Indications [See Note (1)]



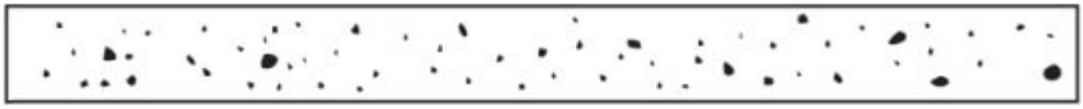
(b) Isolated Indication [See Note (2)]

(c) Cluster

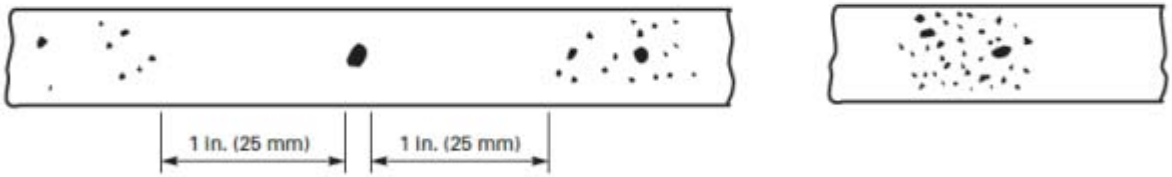
NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Fig 8-4

Charts for *t* Over 1/4 in. to 3/8 in. (6 mm to 10 mm), Inclusive



(a) Random Rounded Indications [See Note (1)]



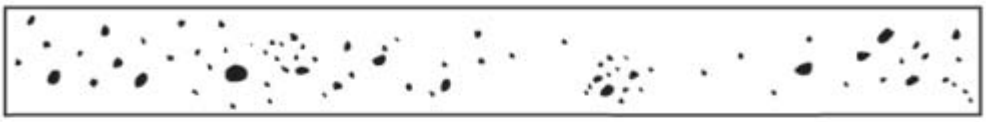
(b) Isolated Indication [See Note (2)]

(c) Cluster

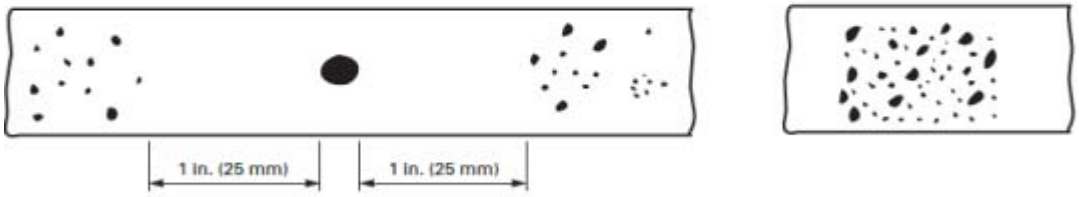
NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Fig 8-5

Charts for *t* Over 3/8 in. to 3/4 in. (10 mm to 19 mm), Inclusive



(a) Random Rounded Indications [See Note (1)]



(b) Isolated Indication [See Note (2)]

(c) Cluster

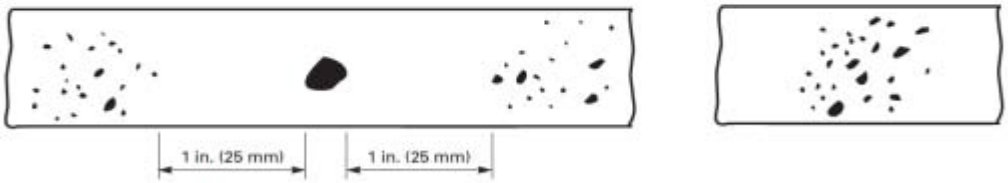
NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Fig 8-6

Charts for t Over $\frac{3}{4}$ in. to 2 in. (19 mm to 50 mm), Inclusive



(a) Random Rounded Indications [See Note (1)]



(b) Isolated Indication [See Note (2)]

(c) Cluster

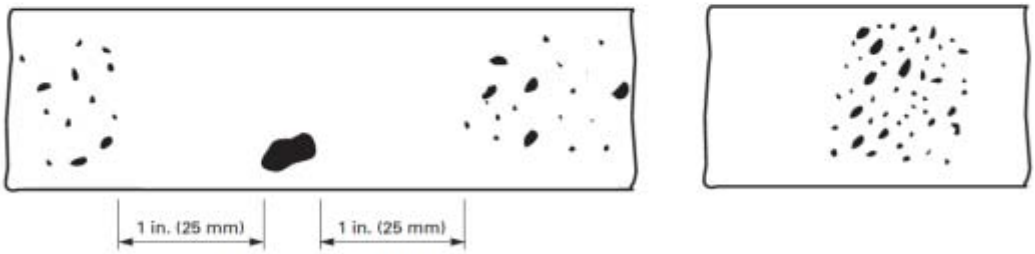
NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Fig 8-7

Charts for t Over 2 in. to 4 in. (50 mm to 100 mm), Inclusive



(a) Random Rounded Indications [See Note (1)]



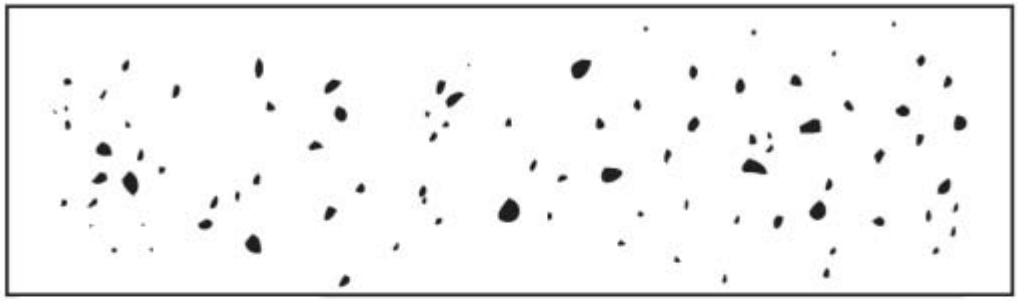
(b) Isolated Indication [See Note (2)]

(c) Cluster

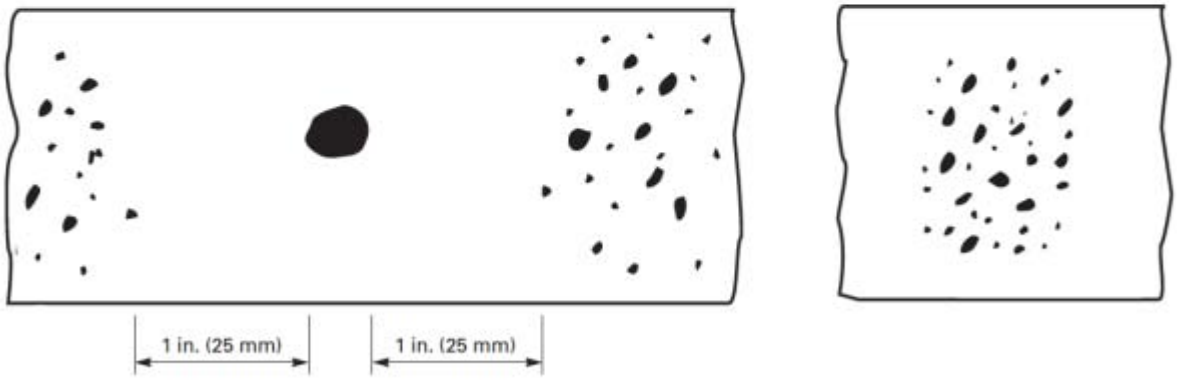
NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1

Fig 8-8

Charts for t Over 4 in. (100 mm)



(a) Random Rounded Indications [See Note (1)]



(b) Isolated Indication [See Note (2)]

(c) Cluster

NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

SAMPLE RT TECHNIQUE SHEET

VENDOR :

SUB VENDOR :

NDT Method and Tech sheet No.		
1	PO No.	
2	QA Ref No.	
3	Scope and Applicability	
4	Personnel Qualification	Certified Radiographer from BARC
		ISNT / ASNT Level II
5	Material	
6	Item condition / Welding process	
7	Dimensions / Diameter	
8	Thickness	
9	Surface condition(As welded/ground)	
10	Source of radiation(Gamma/X-ray), source size	
11	Film (Type, size, and number of shots)	
12	Intensifying screens	0.1mm / 0.15 lead screens
13	Sensitivity requirements(IQI selection/as per applicable code)	
14	IQI number and placements	Source side, (On film side, only when source side placement is not practicable)
15	Geometrical unsharpness	Upto 50mm thick , Ug max 0.50mm
16	SFD	…….(To meet above Ug)
17	Exposure technique	SWSI wherever possible / otherwise DWSI/DWDI
18	Shooting sketch	Attach
19	Density variations permitted	-15% to 30% (w.r.t density on IQI)
20	Ref documents(QAD Gen RT Proc, NPCIL Spec'n etc)	
21	Acceptance standard	Attach
22	Report format	Standard/Attach
23	Any other Information	

Vendor / NDT Agency :

Reviewed by (Sub vendor)	Accepted by (Main vendor)	NPCIL (Procurement/Indentor)	NPCIL (QA) : For NDT std Tech requirements :

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

DOCUMENT NO.: QAD-NDT-PROC-UT-01/ Rev.3

TITLE	**PROCEDURE FOR UT PSI & ISI OF PIPING AND VESSEL WELDS**

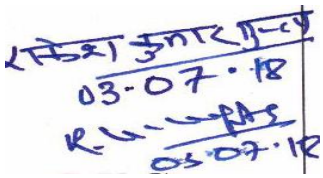
This procedure can be used as reference procedure. A "Technique Sheet/Job specific procedure" is to be prepared identifying the NDT process variables and identifying "Acceptance Criteria" (NPCIL Specification / Code clause) for a given application by the User/Vendor.

REVISION NO.	0	1	2	**3**
DATE OF ISSUE (Month/Year)	March 2001	April 2007	June 2013	June 2018
TOTAL NO. OF PAGES (Excluding cover sheet)	11	24	24	26

REVISION CONTROL SHEET

DOCUMENT NO.: QAD-NDT-PROC-UT-01/ Rev.3

PROCEDURE FOR UT PSI & ISI OF PIPING AND VESSEL WELDS

Rev.No.& date	Description of Revisions		
PP-P-2016 R0	Original		
	Prepared By	Reviewed By	Approved By
PP-P-2017 R1	Editorial changes as per codes/ standards		
	Revised By	Reviewed By	Approved By
	P.V.Khambatkone CE(QA)	M.Mohanbabu CE(ISIS),QA	M.Mohanbabu CE(ISIS),QA
PP-P-2017 R2	Editorial changes(Clause 5,8,13 and 17) as per codes/ standards		
	Revised By	Reviewed By	Approved By
	M.B.Jadhav ACE(QA)	Ranjit Singh ACE(QA)	K.P.Dwivedi ED(QA)
QAD-NDT-PROC-UT-01 R3	Editorial changes(Clause 5,8,13 and 17) as per codes/ standards , Annexure III and Technique sheet added		
	Prepared By	Reviewed By	Approved By
	 Savitkumar.G.Vedeshwar SO/E, QA KGS 3&4	 S.Viswanath ACE(QA)	 R.K.Gupta AD(QA)
	 M.B.Jadhav ACE(QA)		

1.0 PURPOSE

This procedure provides the requirements for Pre-Service and In-Service ultrasonic examination of welds for Piping and Vessels and parent metal wherever applicable.

2.0 SCOPE

2.1 It is in accordance with the requirements of CAN/CSA N285.4 and accordingly, to the procedural requirements of Section XI of the ASME Boiler and Pressure Vessel Code. It applies to full-penetration welds and covers the adjacent base material. It applies to welds of piping and vessels in the thickness range 5 mm to 150 mm. This Procedure shall not be applicable to ultrasonic examination of welds of Reactor Pressure Vessels.

2.2 While the procedure has been prepared for ferritic similar material butt welds, it may be applied with discretion to dissimilar metal welds, austenitic stainless steel welds, fillet welds and for welds where clad is present.

2.3 The procedure utilises the manual contact, pulse-echo shear wave angle-beam examination technique. Additionally, a longitudinal wave normal beam ultrasonic scan for laminations is used which is conducted prior to the angle beam scans. This procedure describes the techniques, the equipment to be utilised and the responsibilities of examination personnel.

2.4 This Procedure shall not applicable for ultrasonic examination using auto/ semi auto mode.

3.0 REFERENCE DOCUMENTS

3.1 This Procedure meets the essential requirements of the following documents:

1) CAN/CSA N285.4-14 (May-2016), “Periodic Inspection of CANDU Nuclear Power Plants”
2) ASME Boiler and Pressure Vessel Code, Section XI, "Rules for In-Service Inspection of Nuclear Power Plant Components", 2017
3) ASME Boiler and Pressure Vessel Code, Section V, "Non-Destructive Examination", 2017

3.2 The document, ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications", 2017 is of relevance.

4.0 PERSONNEL QUALIFICATION

4.1 Personnel who perform ultrasonic examination functions shall be qualified to Level I, Level II or Level III from the ISNT or the ASNT, as further provided below.

4.2 Personnel of contractors should be individually checked and certified in writing for competence by the applicable Site or Station, in accordance with their written Procedure, prior to their use of this Procedure.

4.3 Personnel who perform ultrasonic examinations shall be qualified to Level I or higher.

4.4 Personnel who perform equipment set-up, calibrations and evaluation of results shall be qualified to Level II or higher. All indications of amplitude 50 % DAC and above shall be reviewed by personnel qualified to Level III.

4.5 NPCIL personnel shall supervise and review all stages of performance of this Procedure, according to a Quality Assurance plan or other established practice. Specifically, all indications of amplitude 100 % DAC and above shall be reviewed by NPCIL personnel.

5.0 INSTRUMENTS

Pulse echo type instruments shall be used. The instrument shall be capable of operation at frequencies over the range of at least 1 MHz to 5 MHz (preferred 10 MHz) and shall be equipped with a stepped gain control in units of 2.0 dB or less The instrument, when required because of the technique being used, shall have both send and receive jacks for operation of dual search units or a single search unit with send and receive transducers.

The amplifier shall be of the linear type. The amplitude linearity, amplitude control linearity and time base linearity shall meet the requirements of Annexure 4. These parameters shall be checked at the time of commencement of the examination unless valid records less than six months old exist proving conformance and no repair of instrument has been necessitated. Witnessing personnel may call for rechecks of these parameters at the start of examination or at any time during examination, if there is reason to doubt instrument performance in these regards.

The following Make of instruments have been in use satisfactorily. However Any other make / Model which is satisfying minimum requirements stated above may be utilised viz. M/s. Roop Telsonic, India, M/s. Electronic and Engineering Co., India, M/s Modsonic,India, M/s.Olympus, USA., M/s Ge USA, M/s Sonatest.

Attempts should be made towards use of UT instruments which have Raw Data recording and Playback features. This will enable better Recording / Reporting of Relevant Indications and largely contribute towards comparision and monitoring the relevant indications during subsequent inspections.

Automation as an advancement in the inspection process:

In view of the rapid advancements in technology, a move towards Computerised Data acquisition and Data analysis using Imaging Techniques needs to be considered .

Attempt should be made towards usage of Computerized imaging techniques (CITs) with facility for Encoded scans with off-line analysis features.
The UT instrument, Probe scanner , search units used for CIT applications alongwith the Testing personnel will need to be qualified in accordance with the requirements for flaw detection and/or sizing as specified in the requirement.
A written procedure for CIT applications shall identify the specific test frequency and scan speeds and other relevant parameters to be utilized. Additionally, such procedures shall define the signal processing techniques, and include guidelines for image interpretation, and shall identify the software code/program version to be used.

This information will need to be included in the examination report. (ie. the specific scanning and imaging processes that were used) so that these functions may be accurately repeated at a later time whenever necessary in future inspections.
The computerized imaging process shall preferably include a feature that generates a dimensional scale (in either two or three dimensions, as appropriate) to assist the operator in relating the imaged features to the actual, relevant dimensions of the component being examined.

6.0 REFERENCE BLOCK

6.1 Reference blocks shall be used for screen distance range calibration and distance verifications.

6.2 The block used may be either of the following as suitable for the probe in use:

a) The IIW block, also known as the V1 block; the IIW 2 type with side slots instead of the curved groove is preferable.

b) The Miniature Angle Beam Calibration block; also known as the V2 block.

6.3 These blocks shall be used to determine the exit point of the sound beam and to measure the actual refracted angle of angle beam probes.

6.4 These reference blocks shall be of the same basic material as the material under test.

6.5 For screen distance range calibration, "half - moon" blocks also may be used.

7.0 PROBES

7.1 Angle Beam Probes

7.1.1 For thicknesses up to 30 mm, standard probes of 8×9 mm and of nominal frequency 4 MHz shall be used. If required 2 MHz may be used. One of the probes shall be 45°. The second probe may preferably be 70°, 60° is acceptable if required (e.g., due to need for lower frequency).

7.1.2 For thicknesses above 30 mm, standard probes of 14 x 14 mm or 20 x22 mm and of nominal frequency 2 MHz shall be used. 4 MHz is preferred even for these larger thickness values if performance is satisfactory. One of the probes shall be 45°. The second probe may preferably be 60°. However, 70° is acceptable if required.

7.1.3 For angle beam probes, the exit point of the sound beam and the actual refracted beam angle shall be determined on an IIW reference block and recorded. The miniature angle beam calibration block may be used for this purpose if the probe dimensions are too small for accurate results to be obtained on the IIW block. The permissible error on either side of the nominal angle shall be 2° and the accuracy of measurement shall be 1°. If possible, the exit point shall be marked on the probe.

7.2 Normal Beam Probes

7.2.1 Round 10 or 12 mm diameter, with a frequency of 4 MHz (or 5 MHz) shall be used. It is desirable that the probe is checked to be capable of picking up laminations by confirming it can pick up the backwall echo from a block of approximately 40 % thickness as the job under test. For lower thickness values (below 10 mm), it would be necessary to use a dual probe, a delay-block probe or a higher frequency probe. Any of these options is acceptable. For larger thicknesses, a normal probe may be used and this may be up to 24 (or 25) mm diameter. Probes may be hard-faced or wear membrane types.

8.0 BASIC CALIBRATION BLOCKS

8.1 BasicCalibrationBlockforPiping

8.1.1 The blocks shall be preferably made from material of the same nominal diameter and nominal wall thickness or pipe schedule as the pipe to be examined. However, if required, it is permitted to use material of the same or equivalent P-Number grouping as the pipe to be examined. This P-Number is as specified in Section IX of the ASME Code. Refer Annexure 1.

8.1.2 Calibration reflectors shall be 4 notches. They shall be machined on the outside and inside curved surfaces of the basic calibration block. On each surface, a transverse notch (for longitudinal scan calibration) and a circumferential notch (for axial scan calibration) shall be machined. The positions of the notches relative to each other as well as to the edges of the block, shall be generally in accordance with Annexure 1, such that there is no interference from geometrical features of the block or other notches for each calibration.

8.1.3 Where two or more thicknesses are involved, such as when the weld under examination is between pipes of different thicknesses, the calibration block thickness and notch depth dimensions shall be determined by the thickness of the piping material to which the probe is applied.

8.1.4 When the component material is clad, and the cladding is determined to be important to the examination, the calibration block shall be clad , preferably , by the same welding procedure as the component clad.

8.2 Basic Calibration Block for Vessels

8.2.1 The basic calibration block shall be fabricated from material of the same or equivalent P-Number grouping as the material. This P-Number is as specified in Section IX of the ASME Code. The blocks shall be made from material of the same nominal diameter and nominal wall thickness or pipe schedule as the pipe to be examined. Refer Annexure 2.

8.2.2 The primary calibration reflectors shall be side drilled holes. The holes shall be located as shown in Annexure 2.

8.2.3 In addition, two notches are required; one on either surface, as shown in Annexure 2, and their size shall be as provided in the Table of the same Annexure.

8.2.4 The positions of the above calibration reflectors relative to each other as well as to the edges of the block, shall be generally in accordance with the Annexure 2, such that there is no interference from geometrical features of the block or other notches for each calibration.

8.2.5 Where two or more thicknesses are involved, such as when the weld is between materials of two different thicknesses, the calibration block thickness and notch depth dimensions shall be determined by the thickness of the material to which the probe is applied.

8.2.6 A single curved basic calibration block may be used in the curvature range from 0.9 to 1.5 times the basic calibration block diameter, when contact surface curvature is 500 mm in diameter or less.

8.2.7 For a contact surface curvature greater than 500 mm in diameter, either a flat basic calibration block or a block of essentially the same curvature as the examination contact surface may be used.

8.2.8 When the component material is clad, and the cladding is determined to be important to the examination, the block shall be clad , preferably , by the same welding procedure as the component clad

9.0 CALIBRATION

9.1 General

9.1.1 The following paragraphs describe the calibration requirements for both Piping and Vessels.

9.1.2 Note that the "REJECT" or "SUPPRESSION" control shall be maintained in the "OFF" or minimum position throughout calibration and examination.

9.2 Screen Range Calibration

9.2.1 Normal Beam Screen Range Calibration

9.2.2 The screen distance chosen shall be such that it includes at least t/4 more than the thickest material to which the probe is to be applied.

9.2.3 Observing the back reflections from the applicable reference block, adjust the "MATERIALS CALIBRATION", "RANGE", and "DELAY" controls of the instrument, or their equivalent, to obtain the required sound path distance displayed along the screen baseline.

9.2.4 Screen distance calibration range values shall be selected from the following:

Zero to 10, 20, 25, 40, 50, 100 or 200 mm.

9.2.5 Angle Beam Screen Range Calibration

9.2.6 Use the appropriate scan direction from the table in 12.8, for weld orientation and notch direction.

9.2.7 The screen range chosen shall be the shortest applicable value to include at least ¼ skip past the anticipated examination range for the thickest material to be examined. Please refer to 9.5.2 and 10.4.1 of this Procedure.

9.2.8 Observing the radius echoes from the reference block, adjust the "MATERIALS CALIBRATION", "RANGE", and "DELAY" controls of the instrument to obtain a linear sound path distance displayed along the screen baseline. A "half-moon" block may also be used for this calibration.

9.2.9 Screen distance calibration range values shall be selected from the following:

20, 25, 50, 100, 200, 250 or 500 mm.

9.2.10 Simultaneous Calibration for 45° and 60° DAC

9.2.11 When the same instrument is used for both 45° and 60° examinations, the screen distance calibration may be conducted in the following manner.

9.2.12 The screen range selection shall be based on the angle which will give the larger examination range; i.e. 60°.

9.2.13 Position the 45° probe on the appropriate reference block, and calibrate the instrument test range as described in paragraph 6.2 above. Record all data of range calibration in the calibration record.

9.2.14 Position the 60° probe on the appropriate reference block but do not change the time-base calibration controls of "RANGE", "MATERIAL CALIBRATION", or "DELAY". Observe and record all data of echo positions in the calibration record.

9.2.15 Do not readjust DELAY. Recognise that the screen time-base calibration is still that applicable to the 45° probe. During evaluation, this difference shall be obtained from the recorded data and corrected for. In case the evaluator is not aware of this correction method and recordable indications are detected, recalibrate the time-base solely for the 60° probe and record all details and details of the indications.

9.2.16 This simultaneous calibration for 45° and 60° shall be done only when a Supplementary DAC is not necessary, unless sufficient clarity can readily be still maintained on the instrument's screen.

9.3 Amplitude Calibration, Distance Amplitude Correction (DAC)

9.3.1 Some of the following paragraphs describe preparation of Distance Amplitude Correction (DAC) Curves.

9.3.2 Please note that where markings are to be made on the screen, this should never be to the screen itself (certainly not to the Cathode Ray Tube or equivalent), or to any fixed protective screen. Markings should be applied on transparent overlay sheets placed securely in front of the screen and may be discarded after use; many instruments are

designed to accept such sheets. Ensure that markings on the overlay do not restrict visibility of echoes and that the markings are not cluttered.

9.4 Normal Beam Amplitude Calibration

Identify a region of the work where the back wall amplitude is the highest and using the gain controls, set this amplitude to 80 % of the full-screen-height, ± 10 %. Record calibration parameters in the data sheet, Annexure 3.

9.5 Angle Beam Distance Amplitude Calibration (DAC)

9.5.1 For Piping, use the ID and OD notches of the Calibration Block (Annexure 1). Find out whether the ID notch at ½ skip or the OD notch at 1 skip gives the maximum amplitude and adjust that echo to within 5 % of 80 % of full-screen-height using the Gain controls. This is the primary reference level. The gain controls shall not be further adjusted during calibration and should be locked.

9.5.2 The normal test range is from ½ skip to 1½ skip. However, for Piping, and possibly even for vessels, if the crown of the weld interferes with the front of the probe at its required forward-most location, use the range of 1 skip to 2 skip. Recalibrate the time-base to reflect the increased range.

9.5.3 For Vessels, position the probe on the Calibration Block (Annexure 2) to obtain the maximum response of the t/2 hole such that it is picked up in the ¼ skip, ¾ skip and 1¼ skip positions and find out which position gives the maximum amplitude. Adjust the height of this echo to within 5 % of 80 % of full-screen-height. This is the primary reference level. The gain controls shall not be further adjusted during calibration and should be locked. Additionally, position the probe in turn to pick the ID and OD notches and mark their positions on the screen at their correct amplitudes. These two points each constitute single point Reference Levels.

9.5.4 For both Piping and Vessels, position the probe to obtain the maximized responses from the remaining reflectors and mark them on the instrument screen. Join the points with a smooth curved line which is the Distance-Amplitude Correction (DAC) Curve. The length of the Curve shall extend up to, but not extend more than ¼ skip beyond on either side of the extreme marked points. If a second probe is to be used for the same scan, repeat the above steps for this probe too.

9.5.5 DAC Curves shall have a minimum of 3 points.

9.6 Secondary DAC Calibration

9.6.1 A secondary DAC calibration is necessary if all points in the primary DAC do not have amplitudes of at least 20 %. When required the secondary DAC is constructed as follows:

9.6.2 All secondary DAC curves shall have at least 2 points. The DAC point at 20 % full-screen-height or greater in amplitude and adjacent to a DAC point that falls below 20 % full-screen-height shall be brought up to the primary reference level by

readjusting the gain controls. This point shall then be marked on the instrument screen. The adjacent point, previously at less than 20 % amplitude, shall then be marked on the screen (at its new amplitude). If the secondary DAC contains more than 2 points, join these points with a smooth curved line. If the secondary DAC contains only 2 points, connect them with a smooth curved line, the curvature being similar to that of the original DAC curve at this region, but approximately corrected for vertical scale. In either case the instrument gain settings for this secondary DAC curve shall be recorded in the calibration records.

9.6.3 Mark the gain control setting on the instrument screen against each curve, without obscuring the curves themselves.

9.6.4 If originally as drawn only one point on the DAC is above 20 % full-screen-height in amplitude, the next highest point shall be raised to within 5 % of 80 % full-screen-height by the gain controls and this shall be the primary reference level and shall be recorded in the calibration records.

9.7 Calibration Verification

Sweep Range and DAC Curve Verification

Sweep range and DAC curve calibration shall be verified on the appropriate reference and basic calibration block when any of the following occur:

a) At the start of a series of examinations.

b) Substitution of any of the following: Probe, Probe cable, Power source, Couplant, Ultrasonic instrument, Examination Personnel.

c) At least every 4 hours during the examination.

d) At the finish of the examination.

e) At any time when, in the opinion of the examiner, there is doubt as to the validity of the calibration.

9.8 Calibration Changes

If during recalibration, it is noted that the calibration (which has been in use since the last recalibration) has changed significantly (variation of 5 % on time-base or variation of 2 dB on sensitivity), mark as void all examinations referencing the calibration in question and performed after the last valid calibration, conduct a new calibration and re-examine the voided examination areas.

9.9 Calibration Data

Calibration data shall be recorded on the appropriate Instrument Calibration Record and shall include information and details where required of at least the following:

a) Serial number of the basic calibration block used.

b) Type and serial number of the reference block used.

c) Manufacturer, type reference and serial number of the ultrasonic instrument.

d) Manufacturer, type, frequency, size, beam angle and serial number of ultrasonic probes and wedge details if any

e) Couplant.

f) Date and times of calibration and recalibration.

g) Signature, name and certification level of the examiner conducting the calibration.

h) Probe cable type and length

i) Examination Procedure used and its Revision status

10.0 EXAMINATION

10.1 Identity with Calibration

10.1.1 During the examination, the following parameters of test shall be maintained the same as during calibration:

a) Ultrasonic instrument, its power source, probe and probe cable.

b) Couplant.

c) Examination personnel.

Any change calls for recalibration.

10.1.2 The contact surfaces shall be free from weld spatter, roughness or other conditions which interfere with free movement of the probe or which can impair the transmission of ultrasound.

10.2 Location Zero Reference for Indications

The area to be examined as per this procedure shall have the "Location Zero" reference marked by a "L_0" marking in accordance with Supplement 2, Appendix III, "Supplements", ASME Boiler and Pressure Vessel Code, Section XI.

10.3 Scanning Parameters

10.3.1 No transfer correction shall be used.

10.3.2 Scanning shall be performed at a minimum gain setting of two times (+6 dB) the reference level sensitivity.

10.3.3 Probe movement rate during scanning shall not exceed a speed of 150 mm per second.

10.3.4 During angle beam scans, it is preferable to incorporate an oscillatory skewing (approx +/- 20 deg) movement over and above the normal movement in the beaming direction, in order to improve detection of inclined reflectors. For scans along the side of the weld, the skewing shall be biased into the weld.

10.3.5 Instrument gain settings for scanning shall be recorded on the appropriate Examination Record.

10.4 Scanning Coverage, Overlap

10.4.1 Scanning overlap shall be a minimum of 10 % of the transducer piezoelectric element dimension perpendicular to the direction of the scan. Scanning performed in a direction perpendicular to the weld shall extend as required to examine the weld and a minimum of 25 mm of base material further from the fusion line. Scanning performed in a direction parallel to the weld shall extend a minimum of 25 mm further from the fusion line of the weld.

10.4.2 Technique sheets for each scan shall be prepared to show the coverage by probes beam layout. Limitations which prevent the required coverage shall be documented on the data sheet.

10.5 Base Material Lamination Scan

10.5.1 Before the angle beam examination, a lamination scan using normal beam shall be performed by observing whether back echoes are lost and whether intermediate echoes are noted in the base material. This scan shall cover as much as practical of the volume through which the later angle beam will pass.

10.5.2 Screen distance calibration for this examination shall be performed in accordance with Paragraph 9.2.1 of this Procedure. Scanning sensitivity shall be as required to maintain back reflection at an amplitude between 50 % and 90 % of full-screen-height.

10.5.3 Intermediate echoes having an amplitude equal to or greater than the remaining back reflection shall be recorded. If total loss of back reflection occurs along with one or more intermediate echoes, then the area of total loss of back reflection shall be recorded on the appropriate calibration record.

10.6 Thickness Measurements

In conjunction with the lamination scan described in paragraph 10.5, thickness measurements shall be taken at a minimum of three points; one on the centreline of the weld and one on either side of the weld. These shall be done at 4 locations separated by 90°, starting with L_0 and at any locations with recordable indications. Measurements shall be taken by using an appropriate standard ultrasonic thickness measurement instrument and an approved Ultrasonic Thickness Gauging Procedure is to be used

11.0 PREREQUISITES

11.1 Couplant

11.1.1 Couplants used shall be glycerine, water, oil, grease or commercial grade couplants. For flat horizontal surfaces, water or thin oil will suffice, while for vertical or overhead situations, a more viscous couplant will be indicated. Grease and oil may be mixed, but an adequate quantity shall be prepared because a change in the mixture calls for recalibration.

11.1.2 Couplants used shall be checked for non corrosiveness for the test surface and nearby equipment if required by the referencing specification in accordance with procedures

laid down. For example, for use on stainless steel, requirements may exist for limits on halogens and sulphur content.

12.0 SCAN DIRECTIONS

12.1 All scans shall be from the outside surfaces of the component.

12.2 Initially, either side of the weld, over the entire area required for the later angle beam scans, a scan by normal beam is conducted. This is to locate any laminations or similar flaws which may interfere with the angle beam scans.

12.3 The primary flaw detection is by angle beam examination. Scans required, based on orientation to weld are as follows:

12.4 For the scan at right-angles to the weld (to detect flaws parallel to the weld), the scan shall be by using two angles, one with 45° and the other by either 60° or 70°. These scans shall be from either side of the weld, requiring 4 scans total. However, if scanning is not possible from one side of the weld, the two scans from the other side alone are adequate. However, this information shall be included in the Report.

12.5 For the scan parallel to the weld (to detect flaws transverse to the weld), the scans shall be by using a 45° angle. As usually the weld crown is not ground flat, this would be done using separate scans from each side of the weld. Also, these scans shall consist of clockwise and counter-clockwise scans.

12.6 Any limitations, other than as described in the last paragraph, such scan not possible or only a partial scan is possible, shall be recorded clearly as limitations to Scan. It shall also be reported to the applicable Design Group for resolution.

12.7 It may be noted that the total number of scans above are 9.

12.8 The calibration notches to be used depend on the orientation of the scan with respect to pipe or vessel curvature. For axial scans, use transverse reflectors and for circumferential scans, use axial reflectors. The following Table provides details:

Scans ↓ / Weld Type →	Pipe Butt Weld, or Vessel Circumferential Weld	Pipe Longitudinal Seam, or Vessel Longitudinal Weld
Axial Scan	For indications parallel to weld	For indications transverse to weld
Transverse Reflectors	2 angles (45° and either 60° or 70°), from each side	One angle (45°), in both axial directions
Circumferential Scan	For indications transverse to weld	For indications parallel to weld
Longitudinal Reflectors	One angle (45°), both clockwise and counter-clockwise directions	2 angles (45° and either 60° or 70°), clockwise and counter-clockwise directions

13.0 RECORDING CRITERIA

13.1 Record all recordable indications described below in accordance with the format provided as Annexure 3, along with the relevant Calibration Data. Additionally, a Snapshot of the Relevant Indication should be captured and annexed to the Report Format , duly identified, for future comparison, whenever called for as part of trending / monitoring of these indications during In Service Inspections

13.2 In the case of Vessels, for indications found to originate from the ID or OD surface, comparison must be with reference to the applicable calibration notch (ID or OD). In all subsequent clauses of this Procedure, where percentage DAC is mentioned it shall also mean ID or OD indications with their amplitude expressed as a percentage of the amplitude from the applicable calibration notch.

13.3 All parameters of Calibration and of any ultrasonic reflectors producing a response equal to or greater than 20 % DAC shall be recorded. If the amplitude is below 50 % DAC, only the maximum amplitude and the distance from L_0 shall be recorded.

13.4 Any ultrasonic reflectors producing a response equal to or greater than 50 % DAC shall be recorded in full detail, with information in multiple tracks, separated by the allowable scan index. First, maximise the indication and note the Peak Indication Amplitude (PIA) for this indication. For this track, in one line of the report format, record the values of probe distance from weld centre, the metal path (sound path) of the indication and its amplitude for three distinct groups. The groups are: for the Peak Indication, for the shorter distance to weld along this track where the indication amplitude drops to half PIA and for the longer distance to weld along this track where the indication amplitude drops to half PIA.

13.5 Now, scan along parallel tracks recording, for each track, moving in, say, increasing distance from L_0, record the three groups of information as above for each track, until the indication amplitude drops below half PIA. Further, locate the further end point of the indication beyond the recorded tracks, where the amplitude is half PIA and record this in the first column group, as a further track.

13.6 Repeat the above moving on tracks of decreasing distances from L_0.

13.7 The cause of all ultrasonic reflectors producing a response equal to or greater than 100 % DAC shall be determined by methods which may include plotting, alternate angles of interrogation etc. If the indication is non-relevant, such as due to geometry, this is to be proven unambiguously.

13.8 Any indication producing a response of 100 % DAC or higher and found to be other than geometric in nature, shall be reported separately for evaluation, as described in the Clause 14.

13.9 All limitations in scanning extent or likewise shall be recorded.

14.0 EVALUATION (Acceptance/Rejection/Repair)

14.1 Indications producing a response equal to or greater than 100 % DAC shall be either Evaluated or Repaired.

14.2 Evaluation shall be conducted by the applicable Design Group in accordance with the ASME Boiler and Pressure Vessel Code, Section XI, Article IWA-3000. If the evaluation calls for repair, the repair shall be conducted.

14.3 Repair, if any, shall be duly authorised and shall be carried out as per an approved procedure. After the repair, a fresh and complete ultrasonic examination shall be conducted according to this Procedure and the results stored as a revision to the UT record history of the weld and to serve as fresh base-line data.

15.0 ACCEPTANCE CRITERIA

A) PSI Stage: Recording and Reporting and Acceptance Criteria

1) Indication amplitude < 20% The indication is acceptable. No recording is required.

2) Indication amplitude ≥ 20% but < 50%

   The indication is acceptable. Keep record of amplitude and location from L0.

3) Indication amplitude ≥ 50% but < 100%

   The indication is acceptable. Record the amplitude, location, dimensions and orientation.

4) Indication amplitude ≥ 100%

   Analyse for acceptance according to ASME Section NB/ XI. Keep records of amplitude location dimensions, orientation, type and evaluations performed.

ASME SEC.III, NB 5331

All imperfections which produce a response greaterthan 20% of the reference level shall be investigated to the extent that the operator can determine the shape, identity, and location of all such imperfections and evaluate them in terms of the acceptance standards given in (a)and (b) below.

1) Imperfections are unacceptable if the indications exceed the reference level amplitude and have lengths exceeding:

   a) 1/4 in. (6 mm) for *t* up to 3/4 in. (19 mm), inclusive

   b) 1/3*t* for t from 3/4 in. (19 mm) to 21/4 in. (57 mm), inclusive

   c) 3/4 in. (19 mm) for *t* over 21/4 in. (57 mm)

   where *t* is the thickness of the weld being examined; if a weld joins two members having different thicknesses at the weld, *t* is the thinner of these two thicknesses.

2) Indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.

In general indications that are not meeting the Construction code requirements shall be repaired. In extreme cases with designers consent, evaluation with respect to Sec XI shall be undertaken.

1) Components whose volumetric examination reveals flaws that meet the acceptance standards of Section XI, Article IWB-3000 shall be acceptable. The flaws will be dimensioned and recorded in accordance with Section V,Article 4 and this Subsection.(Ref: ASME Sec III NB 5332).

2) Components whose volumetric examination reveal flaws that exceed the standards of Section XI, ArticleIWB-3000 are not acceptable for service and shall be repaired

B) ISI Stage:

1) Any indication observed and accepted during PSI stage shall be monitored during ISI stage.The flaws will be dimensioned and recorded.

2) If any growth in the indication is observed, the indications shall be evaluated w.r.t ASME Sec XI.

16.0 POST EXAMINATION CLEANING

If called for in the referencing specification, all surfaces of test and any adjacent affected surfaces shall be cleaned to remove couplant materials in accordance with that referencing specification.

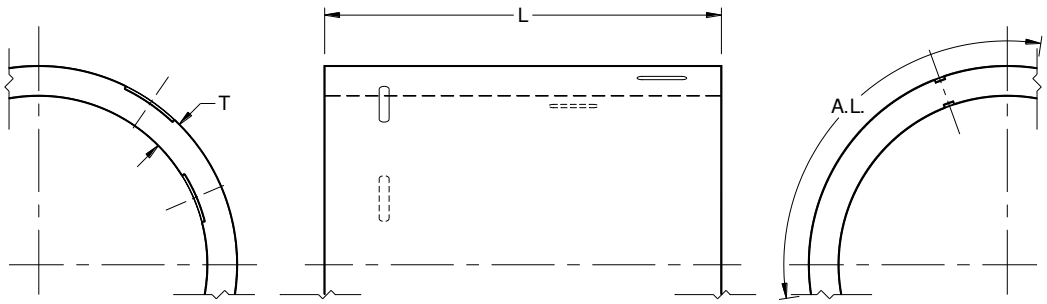
17.0 RECORDS

17.1 Data Records generated in the course of execution of this procedure shall be stored as permanent records and retained as a portion of the examination report. The examination report copies shall be stored at the respective Power Station or Project Site.

17.2 Records shall consist of Calibration Data, Examination Data Records and Snapshots of Relevant indications (as mentioned in Recording Criteria Pt 13 above) and shall be supplemented by information on incomplete scanning such as due to obstructions.

17.3 Each page of the Record shall be signed with the Name, Designation, Company (in the case of Contractors) and NDT Certification Level.

ANNEXURE 1



TYPICAL BLOCK DIMENSIONS

Length L = 200 mm or 8 T, whichever is greater.

Minimum Arc Length (A.L.):

(1) For O.D. 100 mm or less: 270°.

(2) For O.D. greater than 100 mm: the greater of 3T or 200 mm.

NOTCH DIMENSIONS

Length: 25 mm minimum

Width: 3.5 to 6 mm

Depth: 0.1 T, (+0.1, -0.2) mm for T ≤ 8 mm and

0.104 T - 0.00035433 T, (+10 %, -20 %) for 8 < T < 150 mm.

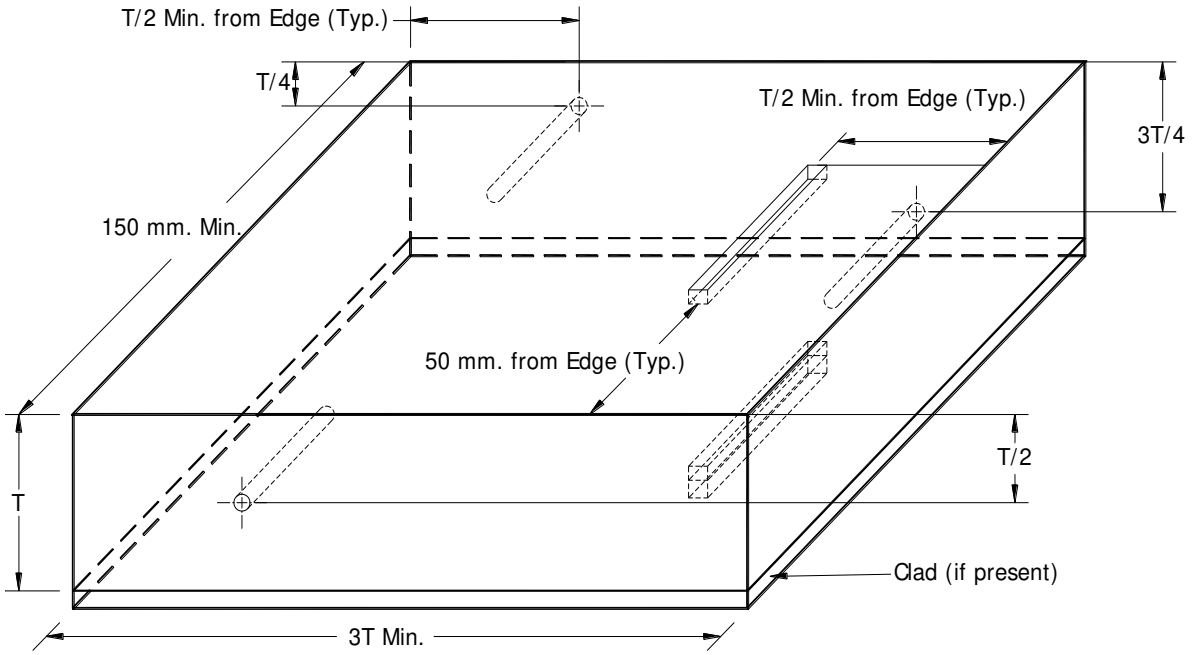
10 % T with tolerance (+ 10 %, - 20 %) of depth

Location: Notches shall be located not closer than $1/2T$ or 1/2 in. (13 mm), whichever is greater, to any block edge or to other notches.

PIPING - ANGLE BEAM CALIBRATION BLOCK (PIPE WELDS)

(From Fig. T-434.3, ASME Section V)

ANNEXURE 2



Weld thickness t	Basic Calibration Block thickness T	Hole Diameter	Notch Size
25 mm or less	19 mm or t	2.4 mm	Width = 3.5 to 6 mm Depth = 2 % T or 1 mm, whichever is greater, in the base metal. Length = 25 mm Min.
Over 25 mm through 50 mm	38 mm or t	3.2 mm	
Over 50 mm through 100 mm	75 mm or t	4.8 mm	
Over 100 mm through 150 mm	125 mm or t	6.4 mm	

NOTES

(a) For each increase in weld thickness of 50 mm of fraction thereof over 250 mm, the hole diameter shall increase 1.6 mm.
(b) Holes shall be drilled and reamed a minimum of 40 mm deep, essentially parallel to the examination surface.
(c) Alternatively, the block may be constructed as shown in Article 4, Appendix J, Fig. J-431 ASME Section V.
(d) Curved surfaces: for curved surfaces, two curved blocks, one for each representative curvature; or two sets of calibration reflectors oriented 90° from each other, shall be used.
(e) Notches may be provided as required.
(f) The tolerance for hole diameter shall be ± 0.8 mm. The tolerance on notch depth shall be + 10 and –20 %. The tolerance on hole location through the thickness shall be ☛3.2 mm.

VESSEL - BASIC CALIBRATION BLOCK

(From Fig. T-434.2.1, Section V, ASME)

ANNEXURE 3 - REPORT FORMATS *Sheet 1 of 5*

ULTRASONIC CALIBRATION DATA REPORT

Report No.: Date: Procedure No.: *PROC-UT-01*

Couplant:

1 Calibration for Lamination Check

Instrument

Make: Model: Serial No.: Power Source:

Probe

Type: Make: Model: Frequency: *MHz* Size: *mm* Shape:

Cable

Make: Type: Length: *m* InstrumentConnector: ProbeConnector:

TestRange: *0 to* *mm*

Range and Amplitude Calibration and Verification

Sl.	Time (Hrs)	Range Calibration						Amplitude Calibration	
		Calibration ReflectorsDistance (mm)			Respective Echo Position (Divisions)			Backwall Echo (%)	Gain (dB)Coarse + Fine
	:								+
	:								+
	:								+
	:								+

2 Calibration for Reflectors Parallel to Weld

Sheet 2 of 5

Instrument

Make: Model: Serial No.: Power Source:

Probe 1

Make: Model/Type: Serial No.: Angle: *45°* Frequency: *MHz* Size: *mm* Shape:

Probe 2

Make: Model/Type: Serial No.: Angle: ° Frequency: *MHz* Size: *mm* Shape:

Cable

Make: Type: Length: *m* InstrumentConnector: ProbeConnector:

Reference Block:

Basic Calibration Block No.: Material: Diameter: *NB* Thickness: *mm*

Range and Amplitude Calibration and Verification

Sl.	Time (Hrs)	Range Calibration						45° Amplitude Calibration							° Amplitude Calibration						
		Reference Block Calibration Reflector Distances (mm)			Respective Echo Positions (Divisions)			Gain (dB)	Calibration Reflector 1		Calibration Reflector 2		Calibration Reflector 3		Gain (dB)	Calibration Reflector 1		Calibration Reflector 2		Calibration Reflector 3	
									Beam Path (mm)	Amplitude (% FSH)	Beam Path (mm)	Amplitude (% FSH)	Beam Path (mm)	Amplitude (% FSH)		Beam Path (mm)	Amplitude (% FSH)	Beam Path (mm)	Amplitude (% FSH)	Beam Path (mm)	Amplitude (% FSH)
					.	.	.	+							+						
					.	.	.	+							+						
					.	.	.	+							+						
					.	.	.	+							+						
					.	.	.	+							+						

Description of Calibration Reflectors: 1 *at* *skip.* 2 *at* *skip.* 3 *at* *skip.*

3Calibration for Reflectors Transverse to Weld

Sheet 3 of 5

Instrument

Make: | Model: | Serial No.: | Power Source:

Probe

Make: | Model/Type: | Serial No.: | Angle: *45°* | Frequency: *MHz* | Size: *mm* | Shape:

Cable

Make: | Type: | Length: *m* | InstrumentConnector: | ProbeConnector:

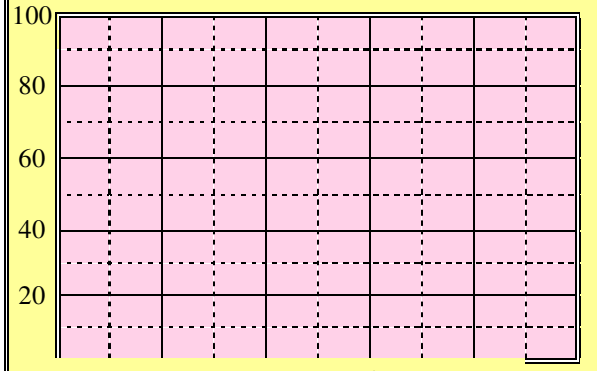
Reference Block:

Basic Calibration Block No.: | Material: | Diameter: *NB* | Thickness: *mm*

Range and Amplitude Calibration and Verification, All DAC Curves

Sl.	Time (Hrs)	Range Calibration: Reference Block Calibration Reflector Distances (mm)			Range Calibration: Respective Echo Positions (Divisions)			45° Amplitude Calibration: Gain (dB)	Calibration Reflector 1: Beam Path (mm)	Calibration Reflector 1: Amplitude (% FSH)	Calibration Reflector 2: Beam Path (mm)	Calibration Reflector 2: Amplitude (% FSH)	Calibration Reflector 3: Beam Path (mm)	Calibration Reflector 3: Amplitude (% FSH)
	:				.	.	.	+						
	:				.	.	.	+						
	:				.	.	.	+						
	:				.	.	.	+						
	:				.	.	.	+						

Distance-Amplitude Correction Curves



Description of Calibration Reflectors:

1 *at* *skip.*

2 *at* *skip.*

3 *at* *skip.*

ULTRASONIC EXAMINATION DATA RECORD

Sheet 4 of 5

Report No.: Date: - - Time: : *to* : *Hrs.*

Weld Identification
System Name: Line or Equipment Name:

Line No.: Joint No.: Joint Type:

Reference, Applicable Calibration Data Sheets, No.:

Parent Metal Details:

	Parent Metal 1	Parent Metal 2
Item:		
Material:		
Nominal thickness:		

1 Measured Thickness Data:

	Parent Metal 1 (PM1)				Parent Metal 2 (PM2)				Weld Metal			
	0°	90°	180°	270°	0°	90°	180°	270°	0°	90°	180°	270°
(mm)												

2 Lamination Check Observations:

3. Angle Beam Scan Observations: *Sheet 5 of 5*

Indication Sl. No.	Track No.	Distance From L_0 (mm)	Thickness (mm)			Maximum Amplitude					Maximun Distance to Weld for 50 % Peak					Minimum Distance to Weld for 50 % Peak					Size *	Depth *
			Parent Metal: Scan Side	Weld	Parent Metal: Opposite Side	Amplitude		Distance to Weld Centre Line	Sweep Reading		Amplitude		Distance to Weld Centre Line	Sweep Reading		Amplitude		Distance to Weld Centre Line	Sweep Reading			
						(% FSD)	% DAC		Divisions	mm	(%FSD)	% DAC		Divisions	mm	(%FSD)	% DAC		Divisions	mm		
A) 45° Scan from PM1 (Pipe) for Indications Parallel to Weld (Circumferential)																						
	No Recordable Indications																					
B) 45° Scan from PM2 (Elbow) for Indications Parallel to Weld (Circumferential)																						
1	*1*																					
	2																					
	No Other Recordable Indications																					

Notes: (1) As an example in using the Table, a few sample entries are provided, in *Italics*.

(2) For indications originating from either surface or near the surface, in addition to data using the Side-drilled hole DAC curve as the reference, provide information separately, equivalent to "% FSD" and "% DAC",using the applicable notch as the reference.

(3) The two Columns marked * are to be filled in if the highest amplitude ≥100% DAC, for all tracks: "Size" is the "Through Depth Size", the linear dimension of the indication in the thickness direction. "Depth" is the "Distance from Scan Surface", the distance from the scan surface to the closest point of the indication.

(4) One set of Thickness values is usually sufficient for each localised indication.

ANNEXURE 4

18.0 SCOPE

This Appendix describes the procedures to be followed and provides the requirements to be met to check and confirm that an ultrasonic test instrument is performing adequately, ifsuch a check is required by a Specification or Procedure.

In using the following directions, indications may need to be maintained on the screen over a length of time, with assurance that there is no change in received echo energy. An immersion fixture with an immersion probe can be very convenient for maintaining this constancy over this period. However, use of such a fixture is not mandatory, though then, care has to be taken that changes do not take place and a recheck shall particularly be done with the old control settings.

If the performance of the instrument does not meet the requirements, it shall be serviced and all performance parameters re-evaluated. Such servicing is not within the purview of UT personnel, but must be conducted by the manufacturer, their authorized agents or other electronic servicing personnel of adequate electronic capability.

A. Amplitude Linearity

This parameter is also called “Screen Height Linearity”.

Use any convenient probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up any two simultaneous indications from any convenient test piece or block which can adjusted such as to provide a ratio of 1:2 between indication heights. That is, one echo must be twice the height of the other. It is immaterial which echo appears first on the time-base.

In order to obtain this condition, one method is to obtain a stepped block (i.e. one with two distinct thicknesses) and scan it from the un-stepped flat side. On scanning the zone of thickness change, two echoes, backwall echoes from the two thicknesses, will be obtained. By selecting an appropriate probe position, the two echoes can be set at any amplitude ratio to each other, in this case, 1:2 or 2:1. Another suitable method can be to use an angle beam block with side drilled holes or notches, where any two of these reflectors or any of these and a corner reflector can be adjusted to the required ratio.

Using Gain, Damping and Filter or any combination of these controls, set the amplitude of the bigger of the two echoes to 80 % full-screen-height.

Without permitting probe movement, re-adjust any of the above controls to change the amplitude of the larger of the two echoes successively from 100 % to 20 % insteps of 10 % full-screen-height. Record the amplitude of the smaller echo in each case. This value must be within 5 % full-screen-height of half the bigger echo, rounded off to the nearest 1 %.

For example, for the case of the bigger echo being at 60 %, the smaller echo must be within the range of 30 % full-screen-height, ± 5 % .

Values outside these call for instrument servicing.

B. Amplitude Control Linearity

Use any convenient probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up any indication from any convenient test piece or block which can readily be maintained stable. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of this echo to 80 % full-screen-height. Only the Gain control or controls shall be adjusted further. Without permitting probe movement, change the Gain by ± 6 dB and± 12 dB and record the amplitudes.

The table below gives the requirements:

Initial Set Value of Amplitude	Gain Control Change	Acceptance Limits of Resulting Amplitude
80 %	- 6 dB	36 to 44 %
80 %	- 12 dB	18 to 22 %
40 %	+ 6 dB	72 to 88 %
20 %	+ 12 dB	72 to 88 %

This check shall be done starting with many representative values of Gain, such that the performance of the Gain control system is evaluated over the entire range of gain control. Where more than one calibrated Gain control is available, such as two separate knobs, each of them shall be checked over their range of control. In order to check the gain controls at various ranges, other controls such as Damping and Filter may be set at different combinations at the start of each test sequence of varying the Gain by ± 6 and ± 12 dB.

The values of 6 and 12 dB may be obtained by combining two of the controls.

When not using the DGS method, depending on the application, it may be adequate to limit the check to the general range of values in use during actual scans.

C. Instrument Time -Base Linearity

This parameter shall be checked at or near range values corresponding to those normally in use.

In the following descriptions, the percentage values refer to the time-base, 0 % and 100 % being the left and right hand extreme graduations.

Select a block of uniform thickness of approximately one-fifth of the range to be checked. Use any convenient normal beam probe, and suitable settings for control settings other than those related to the time-base. Calibrate the instrument time-base to five times this thickness, by positioning the second back-wall echo to 40 % and third back-wall echo to 60 % of the screen. This would require adjustments to the Range, Material Calibration and Delay controls or their equivalent. Lock all of these controls other than Delay.

Using Delay, shift the second back-wall echo to a selected screen division and record the position of the next echo, i.e. the third back-wall echo. Selected screen divisions,

in turn, shall be zero, 20 %, 40 % and 80 %. The expected reading shall, in each case be obviously 20 % larger than the selected screen division.

In each case the permissible error from expected reading shall be within 2 % of the time-base. In instruments with a total of 50 divisions for the time-base, this will correspond to one such small division.

In many instruments, the display does not extend beyond the final time-base mark. In such cases, the check of the last point shall be done in reverse, by shifting the third back-wall echo to the last mark and reading the position of the second back-wall echo.

Specifically in the case of the initial or last portions of the time-base twice the error of 2 %, i.e. 4 % may be permitted. This however, is conditional on checks of the 5 to 25 % or the 75 to 95 % or both respectively, additionally being done and the results being within 2 %, (in instruments with 2% as the small division size, these values may be changed to 6 to 26 % and 76 to 96 % respectively).

ANNEXURE 5

SAMPLE ULTRASONIC TESTING TECHNIQUE SHEET

NDT Method and Tech Sheet No.		
1	PO No.	
2	QA/QS Ref.No./Unit/Area	
3	QAP Reference No.	
4	Scope and applicability	
5	Personnel qualification	ISNT/ASNT-Level-II
6	Material	CS/SS
7	Item Description	
8	Dimension/diameter	As per Approved Drawing
9	Thickness/Length	As per Approved Drawing
10	UT Flaw Detector	Pulse Echo UT Equipment meeting screen height,Amplitude and Time base linearity as per ASME-Sec.5
11	Probe Details	Make, Model, Type, Size, Frequency, Serial Number
12	Couplant	Oil/Grease/Water(Shall be same while calibrating and testing)
13	Surface condition/Preparation	As manufactured suitable for UT(Max.roughness6.35 microns)
14	Sensitivity Requirement	BW method(axial)/1.5 mm FBH method(radial)
15	Scanning Slide	Radial 1.5 mm; DAC method and Axial direction backwall method to the extent possible
16	Scan Area	Radial area with 100% area with 10% overlap.Axial directions from both the ends on full face.
17	Scan Direction	Radial from both side/Axial direction from both ends to the extent possible
18	Scanning Speed	Not more than 150 mm/sec
19	Equipment calibration	Range: Radial 1.5 to 2t Axial (l+-50mm) Appox. Amplitude (PRL): 3point DAC from FBH(Radial)/Axial Backwall method Calibration Check:Start ,Every 4 hours and end of examination
20	Scanning Sketch	Standard(Attach in case of special cases)
21	Recording Criteria	All indications equal and above 100% PRL
22	Reference Documents	
23	Acceptance Standards	
24	Report Format	Attach

Note: The above tech sheet is for Reference/Guidance. User to make detailed Tech sheet.

Prepared By	Reviewed By	Approved By

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

DOCUMENT NO.: QAD/NDT-PROC/UT-06 Rev.: 3

TITLE	PROCEDURE FOR ULTRASONIC EXAMINATION OF STEEL FORGINGS FOR GENERAL PURPOSE

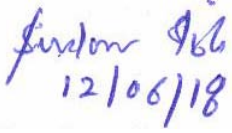
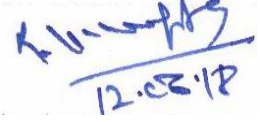
This procedure can be used as reference procedure. A "Job specific procedure/Technique Sheet/" is to be prepared identifying the NDT process variables and identifying "Acceptance criteria" (NPCIL Specification / Code clause) for a given application by the User/Vendor.

REVISION NO.	0	1	2	3
DATE OF ISSUE (Month/Year)	March 2001	May 2007	February 2013	June 2018
TOTAL NO. OF PAGES (Including cover sheet)	15	18	18	20

REVISION CONTROL SHEET

PROCEDURE FOR ULTRASONIC EXAMINATION OF STEEL FORGINGS FOR GENERAL PURPOSE

DOCUMENT NO: QAD/NDT-PROC/UT-06 Rev.:3

Rev. No. & Date	Description of Revisions		
PP-P-2014 R0 (March 2001)	**Description of Revision: Original**		
	Prepared / Revised by S.S. Som SSE(QA), KAPS	Reviewed by M. Mohan Babu ACE (ISIS), QA	Approved by C. Awasthi ED (QA)
PP-P-2014 R1 (May 2007)	**Description of Revision: Editorial changes and changes as per latest codes/standards**		
	Prepared / Revised by P.V. Khambatkone CE (QA) & A.K. Palit, ACE(QA)	Reviewed by M. Mohan Babu CE (ISIS), QA	Approved by M. Mohan Babu CE (ISIS), QA
PP-P-2014 R2 (Feb. 2013)	**Description of Revision:** Editorial changes and changes as per latest codes/Standards.		
	Prepared / Revised by A.K. Palit, ACE(QA)	Reviewed by A.K. Palit, ACE(QA)	Approved by K. P. Dwivedi ED (QA)
QAD/NDT-PROC/UT-06 R3 (June 2018)	**Description of Revision:** Procedure No changed to QAD/NDT-PROC/UT-06. Editorial changes and changes including changes as per latest Codes/Standards.		
	Prepared by  12/06/18 DipankarBej, DCE (QA) UT-Level-III	Reviewed by  12/06/18 Sundar Singh ACE(QA) UT-Level-III	Approved by  12.06.18 Rakesh Kumar Gupta Associate Director (QA) with ED power

1.0 SCOPE

This procedure describes the requirements for ultrasonic examination of steel forgings by pulse-echo, manual contact method and is applicable to forged flanges, bars, and pipe fittings such as Elbows, Tees and Couplings etc. Forgings and forged or rolled bars which are to be bored to form tubular products shall be examined after boring.

1.1 CONTENT

The requirements of this procedure are presented under the following sections:

	Section
Scope	1
Applicable Documents and Standards	2
Qualification of Ultrasonic Examination Personnel	3
Safety Precautions	4
General Requirements	5
Instrumentations	6
Scan Direction	7
Radial Scan	8
Circumferential Scan	9
Axial Scan	10
Reporting	11
Post Examination Cleaning	12

2.0 APPLICABLE DOCUMENTS AND STANDARDS

This procedure is based on the following:

a) ASME Section-V, Article 5, (2017 Edition).
b) ASME Section - III, Subsections NB & NC (2017 Edition).
c) SA-388, Recommended practice for ultrasonic examination of steel forgings, (2017 Edition).
d) DOCUMENT NO: QAD/NDT- PROC/UT-11 Rev: 3, General requirements and Formats for Ultrasonic Examination procedure.

3.0 QUALIFICATION OF ULTRASONIC EXAMINATION PERSONNEL

Scanning shall be carried out by personnel certified as Level I or higher as per SNT-TC-1A of ASNT/IS-13805/ISO 9712-3. Verification of calibration, scanning, analysis of indications and reporting shall be done by personnel certified as Level II or higher as per SNT-TC-1A of ASNT/IS-13805/ISO 9712. The Head of the NPCIL QA Centre/Unit may conduct evaluation tests to check the theoretical and practical capability of the personnel performing UT.

4.0 SAFETY PRECAUTION

Industrial Safety precautions shall be adopted while carrying out the UT.

5.0 GENERAL REQUIREMENTS

5.1 Surface Conditions

The surface of the forging to be examined shall be free of loose scale, paint, dirt etc. The surface roughness of scanning surfaces shall not exceed 6.00µm.

5.2 Couplant

Oil, grease, glycerine, water or cellulose paste shall be used as couplant. Select a suitable couplant based on the surface conditions and orientation; roughness and non-horizontal conditions require a more viscous couplant. Any requirements for protection of the material under test, such as for sulphur and halogen content, shall be met by the couplant.

5.3 Scanning Speed

The scanning speed shall not exceed 150 mm / sec.

5.4 Probe Overlap

To assure complete coverage of the forging volume, the overlap shall be at least 10% of the probe diameter.

5.5 Calibration Identify and Validity

Any change of instrument or control settings (other than temporary changes of controls which operate on fixed steps), probe, couplant or probe cables shall require re-calibration.

Operating variables including the test instrument, its control settings, its power source, probe, probe cable and couplant shall be unchanged once calibrated throughout scanning and evaluation, except for readjustments of gain between evaluation and scan as required during examination.

After initial calibration, rechecks the proper functioning of the equipment shall be checked by the use of the reference specimens, as a minimum -

a) At the beginning of each production run of a given size and thickness of the given material.

b) After each 4 hours or less during production run.

c) At the end of the production run.

5.6 Reject

This control is also called “suppression” in some instruments and shall be maintained in the minimum position (or OFF position, if available) throughout the examination.

5.7 Continuously Variable Controls

Continuously variable controls such as damping and continuously variable gain shall be maintained at either of the extremes of their positions to the extent possible to avoid inadvertent changes.

6.0 INSTRUMENTATION

6.1 Ultrasonic instrument

Pulse-echo type instruments shall be used. The amplitude linearity, amplitude control linearity and time base linearity shall meet the requirements defined in Annexure 4. These parameters shall be checked at the time of commencement of the examination unless valid records less than six months old exist proving conformance and no repair of instrument has been necessitated. Witnessing personnel may call for rechecks of these parameters at the start of examination or at any time during examination, if there is reason to doubt instrument performance in these regards.

6.2 Search Units / Probes. The probes recommended for particular application, are as follows:

6.2.1 Normal Beam probe

a) Size: A maximum active are of 650 mm^2 with 20 mm minimum to 30 mm maximum dimension or 20 mm diameter minimum shall be used.

b) Frequency: Nominally probes of 2MHz to 5 MHz shall be used. Whenever necessary, to compensate for attenuation, lower frequencies upto 0.5 MHz probes may be used.

c) The above shall be selected in such a way that the background noise shall not exceed 25% of the distance amplitude correction curve (DAC).

6.2.2 Angle beam probe

a) Size: Probes equipped from 13X25 mm to 25X25 mm transducers shall be used.

b) Beam Angle: 45^o angle beam search unit shall be used wherever applicable.

c) Frequency: The nominal test frequency shall be 2 to 5 MHz.

d) The above shall be selected in such a way that the background noise shall not exceed 25% of the distance amplitude correction curve (DAC).

The exit point of the sound beam and the actual refracted beam angle of angle beam search unit shall be determined on an IIW reference block. The permissible error on either side of the nominal angle shall be 2^o and the accuracy of measurement shall be 1^o

7.0 SCAN DIRECTIONS

Following scans are applicable for the forgings of following types

a) Solid cylindrical sections: Radial scan (Clause 7.1) and Axial scan (Clause 7.2.1 &7.2.2 as applicable).

b) Hollow cylindrical sections: Circumferential scan (clause 7.3) and axial scan (clause 7.2.2).
c) Disk forging: Radial scan from the circumference (clause 7.1) and axial scan from flat face (clause 7.2.1).
d) Rectangular forgings: Normal beam examination in accordance to the technique mentioned in clause No. 7.1.

7.1 Radial Scan

A radial normal beam scan using longitudinal waves shall be conducted. Scan surfaces shall include all solid cylindrical surfaces of the object. This scan shall be carried out by the Back-Reflection Technique or Distance Amplitude Correction Curve (DAC) method using reference flat bottom hole standard or by using DGS method.

7.2 Axial scan

7.2.1 Normal beam examination

An axial normal beam scan using longitudinal waves shall be carried out, if possible, from both ends of the forging using the Back-Reflection Technique or Distance Amplitude Correction Curve (DAC) method using reference flat bottom hole standard or DGS method.

7.2.2 Angle beam examination

An axial angle beam scan using shear wave shall be carried out in place of axial normal beam scan for cylindrical sections of long length due to attenuation and also for ring and hollow forgings and having an outside diameter to inside diameter ratio of less than 2 to 1 which cannot be examined axially using a straight beam in axial direction.

7.3 Circumferential scan

A circumferential angle beam scan using shear wave from the OD surface shall be carried out for ring & hollow forgings that have a ratio of outside diameter to inside diameter of less than 2 to 1. Use of 35° probe is desirable when the OD / ID ratio is 1.75 to 1 minimum.

8.0 RADIAL SCAN (For Solid Cylindrical Forgings and for Disc Forgings)

This scan shall be carried out by normal probe at all cylindrical surfaces of the test object.

8.1 Calibration Blocks

Calibration blocks shall be of the same material specification and heat treatment as applicable to the test object. However, where the actual forging material belongs to P1 (Refer ASME Sec. IX), use of calibration block made of mild steel is permitted, provided the block is made from forged material. The surface finish at the entry surface of the calibration block should be similar to that of the test object. Prior to

machining the block, the raw material shall be ultrasonic examination checked and shall be adequately defect free.

The hole diameter shall be 3% of the thickness and minimum 3 mm diameter. The holes shall be machined truly flat bottomed, preferably by end milling.

The diameter of the calibration blocks and block length shall be as shown in the Table of Annexure 2.

Whenever DGS Diagrams are used it shall be ensured that all conditions specified in DGS Diagrams are fulfilled. Care shall be taken for setting the range in the instrument to cover full thickness/metal path and instrument dB is set to the requirement of full material beam-path/range as calculated from DGS diagram.

8.2 Time Base Calibration Basis

Mechanically measure the test object diameter or thickness as applicable within 1 mm accuracy. Select a round figure for the required range such as 0 to 50, 0 to 100 or 0 to 200 mm etc. The range shall be such that the first back wall echo is between 60% and 90% of the time base. Calibration on reference block such as V1 block is accepted for the cases where job configuration does not give back wall echo.

8.3 Time Base Calibration Procedure

Calculate the time base position for the first back wall echo. Set the time base controls such that the second back wall echo is set to this value, with the first back wall echo being set to zero. Now, lock all the time base controls other than delay. From this setting, use the delay control to shift the first back wall echo to the calculated position. The time base is now calibrated, lock delay also. Confirm calibration from the position of echoes of other smaller diameter / thickness area wherever possible and correct any errors if necessary.

8.4 Sensitivity Calibration

8.4.1 Back-Reflection Technique (Back-Reflection Calibration Applicable to Forgings with Parallel Entry and Back Surfaces): Adjust the instrument controls to obtain a back reflection approximately between 70% FSH and 80% FSH (Full-Screen Height) from the opposite side of the forging, this is the reference gain and to be noted. Scan the forging at 6 dB more than this reference gain (it is suggested to use the maximum possible amplification setting for scanning of job for better detectability). Evaluation of discontinuities is to be carried out at reference gain setting. Recalibration shall be done for significant changes in section thickness or diameter.

8.4.2 **Setting the primary reference level for DAC Reference block.**

At a suitable gain setting find out which hole provides the highest response. Set the amplitude of this echo to between 70% FSH and 80% FSH using the gain control. This is the reference gain and should not be changed.

8.4.2.1 **Drawing the DAC curve**

Use the instrument screen as a graph. At the metal path corresponding to the first hole (which gives highest response), mark the maximized amplitude of the echo. Repeat this for all the other holes. Draw a smooth line through the points so obtained. This is the distance amplitude correction (DAC) curve. Use a suitable marking pen which should not damage the screen protection sheet.

8.4.3 **DGS Calibration**

If DGS Diagrams are used, guidelines as indicated in diagrams for sensitivity settings shall be followed.

8.5 Scan, Recording and Evaluation

Scan at a gain value higher than the reference gain by 6 dB or more.

Recording & Evaluation shall be done at reference gain for -

a) Any indication whose amplitude equals or exceeds 50% of the reference level.

b) Travelling, clustered or continuous indications that have amplitudes equal to or greater than 25% of the reference level.

c) Any reduction in back reflection (associated with a discontinuity indication) exceeding 20% of the calibration back reflection.

8.6 Acceptance Level

Indications of following nature shall cause for rejection -

a) Any indication whose amplitude exceeds 100% of the reference level,

b) Travelling, clustered or continuous indications that have amplitudes equal to or greater than 50% of the reference level,

c) Reduction in black reflection exceeding 50% not associated with geometric configuration.

d) Any indications exceeding the reference level specified in the DGS method

9.0 CIRCUMFERENTIAL SCAN (For Ring Forgings and Hollow Forgings)

This scan shall be carried out by an angle probe on the OD surface of the test object.

9.1 Calibration Block

Calibration blocks shall be of the same material specification and heat treatment as applicable to the test object. However, where the actual forging material belongs to P1 (Refer ASME Sec. IX), use of calibration block made of mild steel is permitted, provided the block is made from forged material. The surface finish at the contact surface of the calibration block should be similar to that of the test object. Prior to machining the block, the raw material shall be ultrasonic examination checked and shall be adequately defect-free.

The block shall contain rectangular notches on the ID and OD surface in the axial direction and parallel to the axis of forging. The notch depth shall be 3% maximum of the thickness or 6 mm, whichever is smaller and its length shall be 25 mm. The width of the notch shall not be greater than twice its depth. A sketch of the notch is provided as Annexure 3.

9.2 Time Base Calibration Basis

The screen range chosen shall be the shortest metal path distance to include at least 1½ skip distance for the material to be examined. Select a round figure for the required range such as 0 to 20, 0 to 25, 0 to 50 etc. Calibration on reference block such as the V1 block is accepted for cases where the job configuration does not produce a back wall echo.

9.3 Time Base Calibration Procedure

Calculate the time base position for the ID notch and OD notch. Using delay control and time-base control, set the echoes from ID and OD notch to their respective position on the screen.

9.4 Sensitivity Calibration

At the metal path corresponding to ID notch, obtain an indication amplitude of approximately 75% FSH at a suitable gain setting and mark it on the screen. This is the reference gain and should not be changed with above gain setting. Mark the maximized echo amplitude from OD notch corresponding to its metal path on the screen. Draw a smooth line through the points so obtained. This is the distance amplitude correction (DAC) curve.

9.5 Scan, Recording & Evaluation

Scan at a gain value higher than the above reference gain by 6 dB.

Perform the examination by scanning over the entire surface area circumferentially in both clockwise and counter clock wise directions from the OD surface.

Recording & Evaluation shall be done at reference gain for any indication that has amplitude equal to or greater than 50% of the DAC curve.

9.6 Acceptance Level

Any indication above 100 % DAC shall cause for rejection.

10.0 AXIAL SCANNING (for Solid Cylindrical, Disk and Hollow Forgings)

This scanning shall be carried out by a normal probe by flat bottom hole technique or by an angle probe as per applicability mentioned in the clause No. 7.0. Examine forgings, which cannot be examined axially using a straight beam, in both axial directions with an angle-beam search unit.

10.1 Angle Beam Scanning (for Hollow Forgings)

10.1.1 Calibration block

Calibration blocks shall be of the same material specification and heat treatment as applicable to the test object. However, where the actual forging material belongs to P1 (Refer ASME Sec. IX), use of calibration block made of mild steel is permitted, provided the block is made from forged material. The surface finish at the entry surface of the calibration block should be similar to that of the test object. Prior to machining the block, the raw material shall be ultrasonic examination checked and shall be adequately defect free.

The block shall contain rectangular notch on the ID and OD surface in the direction perpendicular to the axis of forging. The notch depth shall be 3% maximum of the thickness or 6 mm, whichever is smaller and its length 25 mm. The width shall not be greater than twice its depth.

10.1.2 Time base calibration basis

The screen range chosen shall be the shortest metal path distance to include at least 1½ skip distance for the material to be examined. Select a round figure for the required range such as 0 to 20, 0 to 25, 0 to 50 etc. Calibration on reference block such as V1 block is accepted for the cases where job configuration does not give back wall echo.

10.1.3 Time base calibration procedure

Calculate the time base position for the ID notch and OD notch. Using delay control and time-base control, set the echoes from ID and OD notch to their respective position on the screen.

10.1.4 Sensitivity calibration

At the metal path corresponding to ID notch, obtain an indication amplitude of approximately 75% FSH at a suitable gain setting and mark it on the screen. This is the reference gain and should not be changed with above gain setting. Mark the maximized echo amplitude from OD notch corresponding to its metal path on the screen. Draw a smooth line through the points so obtained. This is the distance amplitude correction (DAC) curve.

10.1.5 Scanning, Recording & Evaluation

Scanning shall be done axially from both end of the test object. Scan at a gain value higher than the above reference gain by 6 dB.

Perform the examination by scanning over the entire surface area from the circumference of forging axially forward and reverse direction.

Evaluation shall be done at reference gain for any indication that has amplitude equal to or greater than 50% of the DAC curve.

10.1.6 Acceptance level

Any indication above 100 % DAC shall be the cause for rejection.

10.2 Normal Beam Scanning (for Cylindrical Forgings and Disk Forgings)

10.2.1 Calibration Block

Calibration blocks shall be of the same material specification and heat treatment as applicable to the test object. However, where the actual forging material belongs to P1 (Refer ASME Sec. IX), use of calibration block made of mild steel is permitted, provided the block is made from forged material. The surface finish at the entry surface of the calibration block should be similar to that of the test object. Prior to machining the block, the raw material shall be ultrasonic examination checked and shall be adequately defect free.

Prior to machining the block, the raw material shall be ultrasonic examination checked and shall be adequately defect free.

The hole diameter shall be 3% of the thickness and minimum 3 mm diameter. The holes shall be machined truly flat bottomed, preferably by end milling.

The diameter of the calibration blocks and block length shall be as shown in the Annexure 2.

10.2.2 Time base calibration basis

Mechanically measure the test object diameter or thickness as applicable within 1 mm accuracy. Select a round figure for the required range such as 0 to 50, 0 to 100 or 0 to 200 mm etc. the range shall be such that the first back wall echo is between 60% and 90% of the time base. Calibration on reference block such as V1 block is accepted for the cases where job configuration does not give back wall echo.

10.2.3 Time base calibration procedure

Calculate the time base position for the first back wall echo. Set the time base controls such that the second back wall echo is set to this value, with the first back wall echo being set to zero. Now, lock all the time base controls other than delay. From this setting, use the delay control to shift the first back wall echo to the calculated position. The time base is now calibrated, lock delay also confirm calibration from the position of echoes of other smaller diameter / thickness area wherever possible and correct any errors if necessary.

10.2.4 Sensitivity Setting

10.2.4.1 **Back-Reflection Technique (Back-Reflection Calibration Applicable to Forgings with Parallel Entry and Back Surfaces):**

Adjust the instrument controls to obtain a back reflection approximately between 70% FSH and 80% FSH (Full-Screen Height) from the opposite side of the forging, this is the reference gain and to be noted. Scan the forging at 6 dB more than this

reference gain (it is suggested to use the maximum possible amplification setting for scanning of job for better detectability). Evaluation of discontinuities is to be carried out at reference gain setting. Recalibration shall be done for significant changes in section thickness or diameter.

10.2.4.2 Setting the primary reference level for DAC Reference block.

At a suitable gain setting find out which hole provides the highest response. Set the amplitude of this echo to between 70% FSH and 80% FSH using the gain control. This is the reference gain and should not be changed.

10.2.4.3 Drawing the DAC curve

Use the instrument screen as a graph. At the metal path corresponding to the first hole (which gives highest response), mark the maximized amplitude of the echo. Repeat this for all the other holes. Draw a smooth line through the points so obtained. This is the distance amplitude correction (DAC) curve. Use a suitable marking pen which should not damage the screen protection sheet.

10.2.4.4 DGS Calibration

If DGS Diagrams are used, guidelines as indicated in diagrams for sensitivity settings shall be followed.

10.2.5 Scanning, Recording & Evaluation

Scan at a gain value higher than the above reference gain by 6 dB.

Evaluation shall be done at reference gain for -

a) Any indication whose amplitude equals or exceeds 50% of the established DAC curve or DGS reference value.

b) Travelling, clustered or continuous indications that have amplitudes equal to or greater than 25% of the DAC curve or DGS reference value.

c) Any reduction in back reflection (associated with a discontinuity indication) exceeding 20% of the calibration back reflection.

10.2.6 **Acceptance level Indications of following nature shall cause for rejection**-

a) Any indication whose amplitude exceeds 100% of the reference level,

b) Travelling, clustered or continuous indications that have amplitudes equal to or greater than 50% of the reference level,

c) Reduction in black reflection exceeding 50% not associated with geometric configuration.

d) Any indications exceeding the reference level specified in the DGS method.

11.0 REPORTING

All relevant data of the product, Ref document details, Calibration data and examination results shall be entered in the format enclosed in Annexure 1.

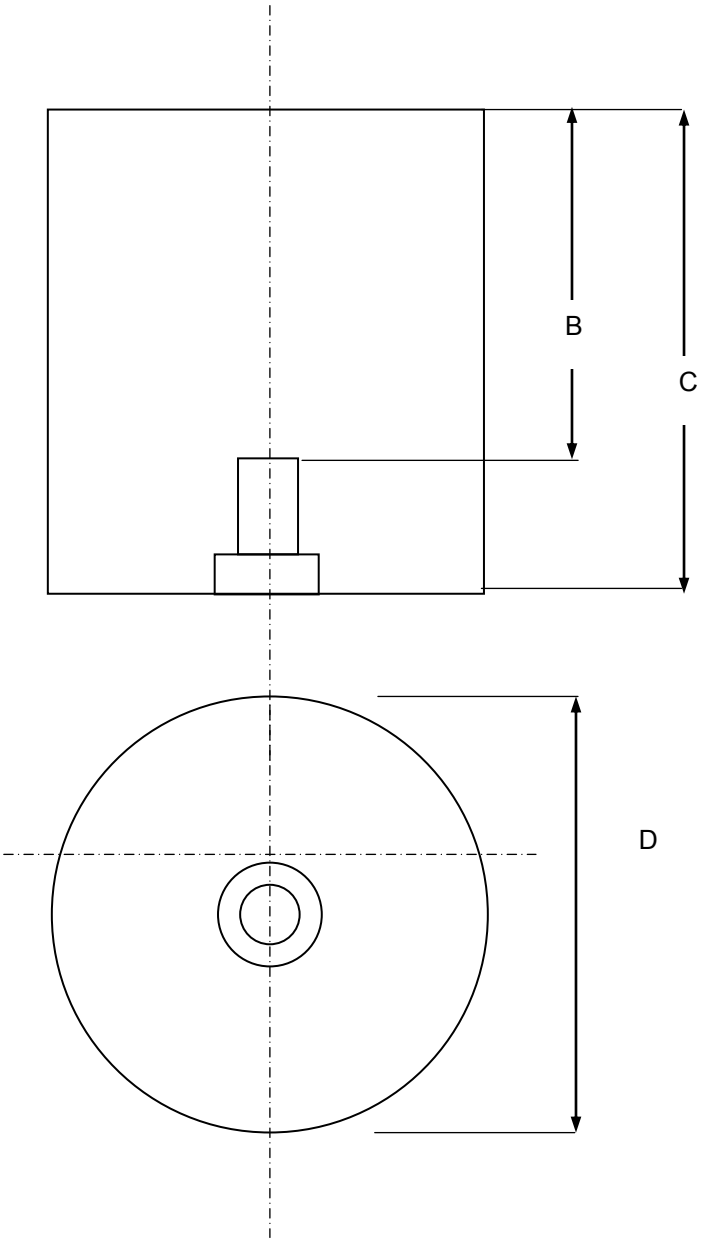
12.0 POST EXAMINATION CLEANING

After the examination the test surface shall be thoroughly cleaned free from grease, oil etc using dry cloth, acetone etc.

ANNEXURE 1

ULTRASONIC EXAMINATATION REPORT			
REPORT NO.:.		DATE OF TESTING :	
REFERENCE PROCEDURE NO.: REFERENCE CODE NO.:		WORK ORDER NO. :	
MATERIAL DESCRIPTION			
MATERIAL :		DIMENSIONS:	
IDENTIFICATION:		SURFACE : MACHINED/ROLLED/WELDED CONDITION	
INSTRUMENT DESCRIPTION			
INSTRUMENT USED :	MACHINE No.:	MAKE:	
SEARCH UNIT :		COUPLANT : OIL / WATER	
CALIBRATION			
RANGE CALIBRATION:			
CALIBRATION : STANDARD		SENSITIVITY:	
METHOD & TECHNIQUE:			
EXAMINATION			
SCANNING:			
EXAMINATION STARTED AT : HRS.		CLOSED AT : HRS	
CALIBRATION RECHECKED AT	1. Hrs	2. Hrs	3. Hrs
OBSERVATION OF RECALIBRATION CHECK	1.	2.	3.
OBSERVATION :			
EVALUATION :			

ANNEXURE 2



STANDARD REFERENCE BLOCK
(For Axial Scanning)

Note: For Radial Scanning, the hole should be drilled radially on the circumference of the Reference Block.

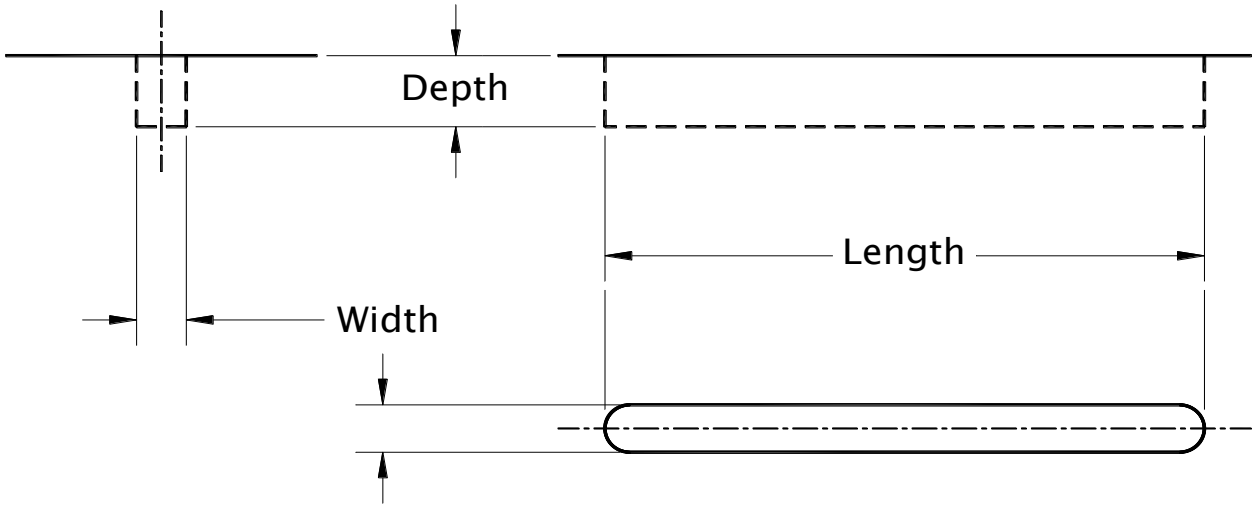
DIMENSIONS OF REFERENCE BLOCKS

Hole diameter (mm)	Metal distance 'B' (mm)	Overall length 'C' (mm)	Diameter 'D' (mm)
3	25	45	50
3	50	70	50
3	75	95	50
3	150	172	75
3	250	273	100
3	B	B+ 19	125

NOTE 'B' FOR ADDITIONAL SUPPLEMENTAL BLOCKS FOR THICKNESS > 250mm.

ANNEXURE 3

Notch Details



ANNEXURE 4

(Appendix to DOCUMENT NO: QAD/NDT- PROC/UT-11 R3, Performance Checks of UT Instrument)

A. SCOPE

This Appendix describes the procedures to be followed and provides the requirements to be met to check and confirm that an ultrasonic test instrument is performing adequately, if such a check is required by a Specification or Procedure.

B. GENERAL

In using the following directions, indications may need to be maintained on the screen over a length of time, with assurance that there is no change in received echo energy. An immersion fixture with an immersion probe can be very convenient for maintaining this constancy over this period. However, use of such a fixture is not mandatory, though then, care has to be taken that changes do not take place and a recheck shall particularly be done with the old control settings.

If the performance of the instrument does not meet the requirements, it shall be serviced and all performance parameters re-evaluated. Such servicing is not within the purview of UT personnel, but must be conducted by the manufacturer, their authorized agents or other electronic servicing personnel of adequate electronic capability.

C. AMPLITUDE LINEARITY

This parameter is also called “Screen Height Linearity”.

Use any convenient probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up any two simultaneous indications from any convenient test piece or block which can adjusted such as to provide a ratio of 1:2 between indication heights. That is, one echo must be twice the height of the other. It is immaterial which echo appears first on the time-base.

In order to obtain this condition, one method is to obtain a stepped block (i.e. one with two distinct thicknesses) and scan it from the un-stepped flat side. On scanning the zone of thickness change, two echoes, backwall echoes from the two thicknesses, will be obtained. By selecting an appropriate probe position, the two echoes can be set at any amplitude ratio to each other, in this case, 1:2 or 2:1. Another suitable method can

be to use an angle beam block with side drilled holes or notches, where any two of these reflectors or any of these and a corner reflector can be adjusted to the required ratio.

Using Gain, Damping and Filter or any combination of these controls, set the amplitude of the bigger of the two echoes to 80 % full-screen-height.

Without permitting probe movement, re-adjust any of the above controls to change the amplitude of the larger of the two echoes successively from 100 % to 20 % in steps of 10 % full-screen-height. Record the amplitude of the smaller echo in each case. This value must be within 5 % full-screen-height of half the bigger echo, rounded off to the nearest 1 %. For example, for the case of the bigger echo being at 60 %, the smaller echo must be within the range of 30 % full-screen-height, ± 5 %. Values outside these call for instrument servicing.

D. AMPLITUDE CONTROL LINEARITY

Use any convenient probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up any indication from any convenient test piece or block which can readily be maintained stable. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of this echo to 80 % full-screen-height. Only the Gain control or controls shall be adjusted further. Without permitting probe movement, change the Gain by ± 6 dB and ± 12 dB and record the amplitudes.

The table below gives the requirements:

Initial Set Value of Amplitude	Gain Control Change	Acceptance Limits of Resulting Amplitude
80 %	- 6 dB	35 to 45 %
80 %	- 12 dB	15 to 25 %
40 %	+ 6 dB	65 to 95 %
20 %	+ 12 dB	65 to 95 %

This check shall be done starting with many representative values of Gain, such that the performance of the Gain control system is evaluated over the entire range of gain control. Where more than one calibrated Gain control is available, such as two separate knobs, each of them shall be checked over their range of control. In order to check the gain controls at various ranges, other controls such as Damping and Filter

may be set at different combinations at the start of each test sequence of varying the Gain by ± 6 and ± 12 dB.

The values of 6 and 12 dB may be obtained by combining two of the controls.

When not using the DGS method, depending on the application, it may be adequate to limit the check to the general range of values in use during actual scans.

E. INSTRUMENT TIME -BASE LINEARITY

This parameter shall be checked at or near range values corresponding to those normally in use.

In the following descriptions, the percentage values refer to the time-base, 0 % and 100 % being the left and right hand extreme graduations.

Select a block of uniform thickness of approximately one-fifth of the range to be checked. Use any convenient normal beam probe, and suitable settings for control settings other than those related to the time-base. Calibrate the instrument time-base to five times this thickness, by positioning the second back-wall echo to 40 % and third back-wall echo to 60 % of the screen. This would require adjustments to the Range, Material Calibration and Delay controls or their equivalent. Lock all of these controls other than Delay.

Using Delay, shift the second back-wall echo to a selected screen division and record the position of the next echo, i.e. the third back-wall echo. Selected screen divisions, in turn, shall be zero, 20 %, 40 % and 80 %. The expected reading shall, in each case be obviously 20 % larger than the selected screen division.

In each case the permissible error from expected reading shall be within 2 % of the time-base. In instruments with a total of 50 divisions for the time-base, this will correspond to one such small division.

In many instruments, the display does not extend beyond the final time-base mark. In such cases, the check of the last point shall be done in reverse, by shifting the third back-wall echo to the last mark and reading the position of the second back-wall echo.

Specifically in the case of the initial or last portions of the time-base twice the error of 2 %, i.e. 4 % may be permitted. This however, is conditional on checks of the 5 to 25 % or the 75 to 95 % or both respectively, additionally being done and the results being within 2 %, (in instruments with 2% as the small division size, these values may be changed to 6 to 26 % and 76 to 96 % respectively).

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
DIRECTORATE OF QUALITY ASSURANCE

PROCEDURE NO.: QAD/NDT-PROC/UT-11 Rev.3

TITLE	PROCEDURE FOR GENERAL REQUIREMENTS OF ULTRASONIC EXAMINATION

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REVISION CONTROL SHEET

PROCEDURE FOR GENERAL REQUIREMENTS OF ULTRASONIC EXAMINATION

DOCUMENT NO.: QAD/NDT-PROC/UT-11 Rev.3

Rev. No. & Date	Description of Revisions		
PP-P-1981 R-0 (March 2001)	Description of Revision: Original		
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	Revised by 11/06/2018 N. Subramaian (UT-Level-III)	Reviewed by 11/06/2018 Sundar Singh (UT-Level-III)	Approved by 11.06.18 R.K.Gupta (AD-QA)

A. SCOPE

This document provides the requirements to be followed when preparing procedures for Ultrasonic Examination (UT). These requirements are to be followed in preparing procedures for UT for critical components or material, for complying with contract requirements when so specified. Such applications call for detailed reporting. This document is prepared for the manual, contact pulse–echo method of Ultrasonic Examination, but may be suitably be adapted for other applications.

Contents:

The requirements of this procedure are presented under the following sections:

	Section
Scope	A
Requirements for Individual clauses of the Procedures	B
Reference	C
Scope for the Referencing procedure	1
Scan Directions	2
Instrumentation	3
Personnel Qualifications	4
General Parameters	5
Calibration Identity	6
Time Base Calibration Requirements	7
Calibration for Sensitivity of Examination	8
Acceptance Standards	9
Reporting Level	10
Reporting Requirements	11
Appendix-1	12

B. REQUIREMENTS FOR INDIVIDUAL CLAUSES OF THE PROCEDURES

Detailed requirements for each clause are elaborated in the following paragraphs (clause No. 1.0 onwards). The same clause numbering system as suggested may be followed if suitable. Examples are given in *italics*, they are non-mandatory and are provided only for a clearer understanding of the requirements.

C. REFERENCE

This document is based on the requirements of ASME Boiler & Pressure Vessel Code, Section V, Article 4 & Article 5 (2017 Edition).

1.0 SCOPE

This clause shall define the material or component to which the procedure applies. Mention shall be made of the end use as well as the systems to which the component or material will be incorporated into at site. The fabrication status of the component, namely the heat-treatment stage, machining status and related aspects shall be specified. References including the Purchase Order Number, Sub-order Number if any, drawing numbers with part number shall be mentioned. This clause shall also define the UT method which is applicable. An example is *"The Manual, Pulse-Echo Contact Method, using Longitudinal Waves and by Normal Beam Examination*".

2.0 SCAN DIRECTIONS

This clause shall list the specific scans necessary, with information regarding the beam propagation direction. An example, applicable to the UT of round bars is:
Two scans are required. They are:

2.1 Radial Normal Beam Scan, using Longitudinal Waves.

2.2 Axial Normal Beam Scan, using Longitudinal Waves.

3.0 INSTRUMENTATION

This may be in two or more parts.

3.1 This clause should provide requirements for the ultrasonic instrument. It may provide a list of instruments evaluated as suitable. The list shall mention makes as well model names or model numbers. Any additional requirements for checks on instrument performance parameters (such as Amplitude Control Linearity) shall also be specified. Appendix 1 provides details of standard performance checks.

3.2 This clause shall specify the probe (search unit) to be used. This shall be done for each of the required scans. As an example the following table is provided:-

Search Units

	SCAN	SIZE	FREQUENCY	ANGLE	MAKE*	MODEL	TYPE
2.1	Radial	24 mmϕ	2 MHz	0°	M/s Krautkrämer	B2S	Note 1
		24 mmϕ	4 MHz	0°	M/s Krautkrämer	B4S	Note 1
		10 mmϕ	4 MHz	0°	M/s Krautkrämer	MB4S	Note 1
2.2	Axial	24 mmϕ	2 MHz	0°	M/s Krautkrämer	B2S	Note 1
		24 mmϕ	4 MHz	0°	M/s Krautkrämer	B4S	Note 1
		10 mmϕ	4 MHz	0°	M/s Krautkrämer	MB4S	Note 1

Note 1: All probes are of replaceable wear membrane type and shall be of either the 'D' or 'E' series.

**Note 2: Indian make probes such as those by M/s EEC or M/s Roop Telsonic Ultrasonics can also be used.*

3.3 A further clause may specify any special requirements regarding probe cable type, length etc., and may specify any additional instrumentation such as recording equipment or probe preamplifiers.

4.0 PERSONNEL QUALIFICATIONS

This clause shall define requirements for Personnel Qualification. Levels of qualification of personnel for performance of test and for performance of evaluation shall be separately specified. The recommended qualifications are from:

For Level III	*The American Society for Non-Destructive Testing (ASNT), The Indian Society for Non-Destructive Testing (ISNT) and UNDP/IAEA, to ISO Standards.*
For Levels I & II	*Preferably only from the Indian Society for Non-Destructive Testing (ISNT). However, qualifications according to UNDP, IAEA or ASNT is also acceptable.* *Personnel qualified to Level III as defined in the previous clause.* *The QA Head of Unit may conduct additional evaluation tests to ensure theoretical and practical competence of personnel.*

5.0 GENERAL PARAMETERS

This clause shall define requirements common to all scans. These may be regarding permissible couplants, job surface finish, permissible scanning speed, calibration verification interval, scanning coverage and overlap between scans. Any other requirements necessary for the examination shall be added here, such as that on cylindrical surfaces, the relative movement between probe and job for scan shall always be circumferential and not axial, unless matching shoes are used.

Any parameter not common to all scans must be detailed separately, preferably in clauses detailing scan requirements. This may be taken care by preparing suitable technique sheets by identifying the UT Technique variables for that particular application (*i.e weld joint wise technique sheets when weld joint configurations are not unique in a vessel/equipment*), this may include (in addition to other variables) scanning directions, sensitivity requirements for each scan and acceptance criteria.

This clause shall also require that the REJECT or SUPPRESSION control shall be maintained at the minimum or OFF position throughout the examination.

6.0 CALIBRATION IDENTITY

This clause shall define that operating variables including control settings such as couplant shall be unchanged between calibration, scanning and evaluation and shall define permitted and necessary changes such as for re-adjustments of gain between evaluation and scan. For example the clause may read:

Any changes of instrument, search unit, couplant or probe cables shall call for re-calibration. Once calibrated, all instrument control settings shall not be changed throughout the examination. However gain controls may be changed as follows:

Increase gain by 6 dB from the calibration gain for scanning. Upon locating an indication, the gain is to be brought down back to the calibration gain for evaluation. After evaluation, prior to continuing with the scan, reset the gain again to 6 dB above the calibration gain.

7.0 TIME-BASE CALIBRATION REQUIREMENTS

This clause shall detail the basis for time-base calibration. Details of any reference block shall be provided. It is recommended that time-base calibration for normal beam shall utilize the job itself and not any separate block, even a reference block. For angle beam calibration it is generally required to use a separate block and this may be identified as "*the VI block or the IIW block*" or the "*V2 block*".

8.0 CALIBRATION FOR SENSITIVITY OF EXAMINATION

This clause shall specify the requirements for setting the test sensitivity. It shall include details or any calibration blocks, which may be necessary. For details of calibration blocks, sketches shall invariably be attached and these sketches shall be referred to in this paragraph. The clause must describe requirements such as preparing DAC curves, their marking on screen, gain additions for scan etc. it must mention that all evaluations shall be done at the calibration gain setting.

In case the DGS method of evaluation is envisaged, this clause must provide detailed information to enable the operator to set the sensitivity such as that an indication of just minimum reportable size will be sensed at a specified amplitude, such as 80%.

9.0 ACCEPTANCE STANDARDS

This clause shall specify the requirements for the Acceptance / Rejection decision in unequivocal terms. It shall be permissible to have different acceptance levels for different portions of the component.

Acceptance based on the type of the discontinuity (such as Lack-of-Fusion or Porosity) is not recommended, because characterizing indications is quite difficult by UT methods. The clause should include any minimum distance between otherwise acceptable indications.

10.0 REPORTING LEVEL

This clause shall specify the criteria by which indications are to be classified as recordable or otherwise. Wherever possible, the recording level shall be uniform for all portions of the component. The recording level shall be more stringent than the reject level, preferably by a factor of 6 dB.

This clause shall contain detailed directions to establish orientations and dimensions to locate the probe location and hence indication location for all possible areas of the component. It is recommended that this be clarified by a sketch.

11.0 REPORTING REQUIREMENTS

This clause shall describe all the parameters, which shall be reported in the written report describing the examination results. It is recommended that a reporting format be appended to the procedure and referred to here. The parameters shall be so chosen such that, a reconstruction of the examination is possible for purposes of verification or analysis.

The following parameters shall be included as a minimum:

a) Component Description.
   i) Drawing Number
   ii) Serial Number
   iii) Name of Assembly to be integrated into, and its identification if available
   iv) Identifying Marks
b) Procedure Number, Revision Number, Date, Approval Status.
c) Date and Time of Examination
d) Examination Personnel details, including NDT Qualification.
e) Instrument Type, Serial Number, Calibration Status, next Calibration Date
f) Probes, Types, Serial Numbers, if necessary, also measurement results for Beam Angle, Exit Point.
g) Cables, Types, Lengths, End Connectors, Couplant.
h) Reportable Indication List, with sketch of reference marks for reporting.
i) Rejectable Indication List, with sketch of reference marks for reporting.
j) Acceptance / Rejection decision.
k) Name and signature with Date of the examiner and the evaluator.

12.0 REPORT FORMS

This clause shall describe the requirements of forms for reporting examination parameters, information and results of the examination. Sample report forms shall be included. The forms should permit efficient, unambiguous and complete recording of all test parameters as well as of test results.

The following are recommended:

Report forms shall not include ‘boxes’ from which one or more box shall be selected by tick-marking; instead blank areas shall be provided for entering the information by actual writing in of data.

While entering information in the report, any errors shall be neatly crossed out, such that the wrong entry is still legible. Corrections shall now be entered and the correction validated by signature.

APPENDIX 1

(Performance check of instrument)

A. SCOPE

This Appendix describes the procedures to be followed and provides the requirements to be met to check and confirm that an ultrasonic test instrument is performing adequately, if such a check is required by a Specification or Procedure.

B. GENERAL

In using the following directions, indications may need to be maintained on the screen over a length of time, with assurance that there is no change in received echo energy. An immersion fixture with an immersion probe can be very convenient for maintaining this constancy over this period. However, use of such a fixture is not mandatory, though then, care has to be taken that changes do not take place and a recheck shall particularly be done with the old control settings.

If the performance of the instrument does not meet the requirements, it shall be serviced and all performance parameters re-evaluated. Such servicing is not within the purview of UT personnel, but must be conducted by the manufacturer, their authorized agents or other electronic servicing personnel of adequate electronic capability.

C. AMPLITUDE LINEARITY

This parameter is also called “Screen Height Linearity”.

Use any convenient probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up any two simultaneous indications from any convenient test piece or block which can adjusted such as to provide a ratio of 1:2 between indication heights. That is, one echo must be twice the height of the other. It is immaterial which echo appears first on the time-base.

In order to obtain this condition, one method is to obtain a stepped block (i.e. one with two distinct thicknesses) and scan it from the un-stepped flat side. On scanning the zone of thickness change, two echoes, backwall echoes from the two thicknesses, will be obtained. By selecting an appropriate probe position, the two echoes can be set at any amplitude ratio to each other, in this case, 1:2 or 2:1. Another suitable method can be to use an angle beam block with side drilled holes or notches, where any two of these reflectors or any of these and a corner reflector can be adjusted to the required ratio.

Using Gain, Damping and Filter or any combination of these controls, set the amplitude of the bigger of the two echoes to 80 % full-screen-height.

Without permitting probe movement, re-adjust any of the above controls to change the amplitude of the larger of the two echoes successively from 100 % to 20 % in steps of 10 % full-screen-height. Record the amplitude of the smaller echo in each case. This value must be within 5 % full-screen-height of half the bigger echo, rounded off to the nearest 1 %. For example, for the case of the bigger echo being at 60 %, the smaller echo must be within the range of 30 % full-screen-height, ± 5 %. Values outside these call for instrument servicing.

D. AMPLITUDE CONTROL LINEARITY

Use any convenient probe. Set the Suppression or Reject control to minimum (or OFF, if available) which value shall be maintained undisturbed further. Pick up any indication from any convenient test piece or block which can readily be maintained stable. Using Gain, Damping and Filter or any combination of these controls, set the amplitude of this echo to 80 % full-screen-height. Only the Gain control or controls shall be adjusted further. Without permitting probe movement, change the Gain by ± 6 dB and ± 12 dB and record the amplitudes.

The table below gives the requirements:

Initial Set Value of Amplitude	Gain Control Change	Acceptance Limits of Resulting Amplitude
80 %	- 6 dB	35 to 45 %
80 %	- 12 dB	15 to 25 %
40 %	+ 6 dB	65 to 95 %
20 %	+ 12 dB	65 to 95 %

This check shall be done starting with many representative values of Gain, such that the performance of the Gain control system is evaluated over the entire range of gain control. Where more than one calibrated Gain control is available, such as two separate knobs, each of them shall be checked over their range of control. In order to check the gain controls at various ranges, other controls such as Damping and Filter may be set at different combinations at the start of each test sequence of varying the Gain by ± 6 and ± 12 dB.

The values of 6 and 12 dB may be obtained by combining two of the controls.

When not using the DGS method, depending on the application, it may be adequate to limit the check to the general range of values in use during actual scans.

E. INSTRUMENT TIME -BASE LINEARITY

This parameter shall be checked at or near range values corresponding to those normally in use.

In the following descriptions, the percentage values refer to the time-base, 0 % and 100 % being the left and right hand extreme graduations.

Select a block of uniform thickness of approximately one-fifth of the range to be checked. Use any convenient normal beam probe, and suitable settings for control settings other than those related to the time-base. Calibrate the instrument time-base to five times this thickness, by positioning the second back-wall echo to 40 % and third back-wall echo to 60 % of the screen. This would require adjustments to the Range, Material Calibration and Delay controls or their equivalent. Lock all of these controls other than Delay.

Using Delay, shift the second back-wall echo to a selected screen division and record the position of the next echo, i.e. the third back-wall echo. Selected screen divisions, in turn, shall be zero, 20 %, 40 % and 80 %. The expected reading shall, in each case be obviously 20 % larger than the selected screen division.

In each case the permissible error from expected reading shall be within 2 % of the time-base. In instruments with a total of 50 divisions for the time-base, this will correspond to one such small division.

In many instruments, the display does not extend beyond the final time-base mark. In such cases, the check of the last point shall be done in reverse, by shifting the third back-wall echo to the last mark and reading the position of the second back-wall echo.

Specifically in the case of the initial or last portions of the time-base twice the error of 2 %, i.e. 4 % may be permitted. This however, is conditional on checks of the 5 to 25 % or the 75 to 95 % or both respectively, additionally being done and the results being within 2 %, (in instruments with 2% as the small division size, these values may be changed to 6 to 26 % and 76 to 96 % respectively).

NUCLEAR POWER CORPORATION OF INDIA LTD.

(A Government of India Enterprise)

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TECHNICAL SPECIFICATION

FOR

THERMAL INSULATION

REF. USI NO. : 30000, 40000, 70000

PREPARED BY	:	Arunava Sinha	Arunava Sinha. 02/05/08	2 May 2008
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Rev. No.	*Date*	*Description of Revision*	*Prepared By*	*Checked by*	*Reviewed by*	*Approved by*

1.0 SCOPE

This specification covers requirements for the supply, installation and performance guarantee of thermal insulation for piping, equipment and ducting in the nuclear and conventional portions of the Atomic Power Plants.

2.0 CONTENTS

The requirements of this specification are presented under the following section headings:

Scope	:	1.0
Contents	:	2.0
Applicable Specifications and Drawings	:	3.0
General Description	:	4.0
Materials	:	5.0
Insulation Thickness	:	6.0
Insulation Application Procedure	:	7.0
Examination and Testing	:	8.0
Quality Assurance Plan (QAP)	:	9.0
Quality Assurance by the Purchaser	:	10.0
Submission of Technical Documentation	:	11.0
Other Requirements	:	12.0

3.0 APPLICABLE SPECIFICATIONS AND DRAWINGS

3.1 Specifications:

Reference is made to the following standard specifications which form part of this specification.

IS:277	:	Galvanized steel sheets (plain and corrugated) – Specification
IS:3144	:	Methods of test for mineral wool thermal insulation materials
IS:3346	:	Method of determination of thermal conductivity of thermal insulation material (Two slab guarded hot plate method).
IS:5688	:	Method of test for preformed block type and pipe covering type thermal insulation.
IS:5724	:	Methods of test for thermal insulating cements.
IS:8154	:	Preformed calcium silicate insulation (for temperature up to 650°C)
IS:8183	:	Bonded Mineral Wool.
IS:9428	:	Preformed calcium silicate insulation (for temperature up to 950°C)

IS:9489	:	Method of test for thermal conductivity of thermal insulation by means of heat flow meter
IS:9742	:	Code of practice for sprayed mineral wool for thermal insulation.
IS:9842	:	Specification for pre-formed fibrous pipe insulation
IS:12432	:	Code of practice for application of spray applied insulation
IS:12436	:	Specification for Preformed rigid polyurethane (PUR) and Poly isocyanurate (PIR) foams for thermal insulation
IS:13205	:	Code of Practice for the application of polyurethane by In-situ pouring method.
IS:14164	:	Code of practice for the application and finishing of thermal insulating material at temperatures above 80 deg. C and up to 700 deg. C.
ASTM C-795	:	Standard specification for thermal insulation for use in contact with austenitic stainless steel.

3.2 Drawings:

A list of all drawings accompanying this specification and forming a part of it will be included in tender document.

4.0 GENERAL DESCRIPTION

Thermal insulation is provided for piping, equipment and ducting to minimize the heat transfer from it. Apart from selecting good insulation material, workmanship during pre-fabrication and erection is also very important in insulation applications. Heat leakage sources of all forms are to be identified and thermal bridges avoided by deploying thermal breaks of Ceramic Fibre paper wherever possible. Brief description of items to be insulated and the corresponding insulation procedure to be followed are given below:

SR No	*ITEMS*	Application Procedure Refer clause No.
4.1	Cold Carbon Steel Piping and Equipment & G.I. and C.S. Ducting	*7.1.1, 7.1.2, 7.1.3, 7.1.4*
4.2	Cold Stainless Steel Piping & Equipment	*7.1.3*
4.3	Hot Carbon Steel Piping & Equipment	7.2.2
4.4	Turbine & Associated Equipment	7.3
4.5	Hot Stainless Steel Piping & Equipment	7.2.1 & 7.2.2

5.0 MATERIALS

5.1 Insulation Materials:

The bidder shall submit his offer based on the materials mentioned in paragraph 5.1.1, 5.1.2, 5.1.3, 5.1.4 & 5.1.5 of this Specification. However, the bidder may submit alternate offers for specified areas based on other insulating materials (e.g. Ceramic Fibre, Micro porous insulation (Reference Microtherm, UK) or Mirror insulation meeting performance requirements and intent of this Specification. For cladding over insulation systems prone to mechanical damage – both hot and cold, mechanically stronger ZINCALUME 150 gsm or GALVANISED 275 gsm, with a gauge one step lower than specified for aluminium cladding shall be considered. In such offers the bidder shall clearly indicate items of equipment / component listed in clause 4.0 to which these offers relate and provide detailed insulation procedure in a manner similar to that outlined in clause 7.0 of this Specification. Bidder shall also provide the justification for using the alternative material. The insulation materials specified herein shall be suitable for a cumulative irradiation dose of 100 M. rads without any effect on its intended performance.

5.1.1 Preformed / In-situ Polyurethane Foam: (PUF)

Preformed/in-situ polyurethane shall conform to IS-12436. The thermal conductivity or "K" value when determined as per IS 3346/IS 9489 shall not exceed figures as given below:

Température (Dégrée. C)	"K" In W/M-K
0	0.021
10	0.022
20	0.024

Slabs and pipe sections shall have a normal density of 36 kg/m^3 and where pipe supports are outside the insulation on 40 mm nominal or larger diameter pipes, polyurethane pipe sections of appropriate density (minimum 120 kg/m^3) shall be used.
The comprehensive strength (at 10% deformation), water vapour transmission, dimensional stability and horizontal burning characteristics shall be as per IS: 12436. Material shall be irradiation resistance.

The tolerances on slabs and pipe section shall be in accordance with IS: 12436.

5.1.2 Resin Bonded Mineral Wool:

Resin bonded mineral wool mattresses conforming to IS:8183 having normal density of 140/150 kg/m^3 and thickness varying from 25 to 100 mm shall be used.

Material should conform to the requirements of IS: 8183 in respect of moisture resistance non-corrossivity, non-hygroscopity and shall be proof against rot, vermin and fungus. These mattresses shall have thermal conductivity as under:

Mean Temp. Deg. C.	***Thermal Conductivity W/M-K(Maximum)***
100	0.042
200	0.054
300	0.072

Attempt shall be made to achieve lower thermal conductivity.

Resin bonded mineral wool mattresses shall not have chloride content more than 25 ppm. Test shall be conducted as per IS-3144.

It shall be supplied in the form of mats which is enclosed on one side with G.I. wire netting of specification 12.5 x 0.71 mm hexagonal construction.

Tests for thermal material shall be carried out as per IS: 8183 and IS: 3144 and test certificate will be submitted with each batch of material. For all austenitic steel surfaces, mineral wool insulation conforming to ASTM C-795 shall be used.

Resin bonded mineral wool shall also be incombustible and of fire barrier quality, irradiation resistant, odourless, easy to cut and maintain.

5.1.3 **Snap-On Type Rigid Pipe Sections Of Resin Bonded Mineral Wool:**

Pre-formed snap-on type rigid pipe section of resin bonded mineral wool conforming to IS: 9842 shall be used for all piping up to and including 350 NB.

Pipelines larger than (350 mm NB) and special area such as fittings would require insulation with bonded mattresses.

The pipe section (snap-on type) shall be strong, durable, non-corrosive, non-hygroscopic, water repellent, and odourless. The insulation shall also be incombustible, rot, vermin and fungus proof. If the insulation thickness requirement is higher than available pipe section it can be supplemented with mattress to achieve requisite thickness.

5.1.4 Calcium Silicate (Asbestos Free) :

Calcium silicate (asbestos free) with addition of insulation binders and corrosion inhibitors shall be used in the form of blocks for regular surfaces and wet cement for irregular surfaces, where use of pre-formed blocks is not possible. The material shall conform to IS: 8154.

Thermal conductivity of the material shall not exceed 0.089 W/M°K at 300 deg. C mean test temperature when tested as per IS: 3346. Insulation should be suitable for application up to 600 deg. C.

Blocks made from calcium silicate powder or mixture of calcium silicate fibres shall have a nominal density of 250 kg/m^3 in dry state. The compressive strength of the blocks at 10% deformation when tested as per IS: 5688 shall not be less than 1.5 kg/cm^2. Blocks shall be fire resistant and thermally stable at temperature of 600 deg. C.

This insulation material and the primer shall not have soluble chloride content more than 25 ppm. Water used for wet mixing shall be free of halides. Calcium Silicate may be used for the equipment having irregular geometry for example TG and portion of body of large size pumps, (BFP, PCP).

5.1.5 **Spray Mineral Wool:**

Spray mineral wool conforming to requirements of IS: 9742 shall be considered for application on irregular surfaces.

5.2 Other Materials:

5.2.1 Cold Stickers, Vapour Barrier, Joint Sealant:

5.2.1.1 Cold stickers (e.g. MAS-83 compound) shall be used for adhering and sealing insulation material.

5.2.1.2 Vapour barrier mastic shall be fire resistant, non-bituminous such as MAS-131 fire resistant aluminium mastic and capable of being applied by trowel or brush to the required thickness / covering capacity as per manufacturer's specification.

5.2.1.3 Joint sealant shall be a vapour barrier sealer available as a soft paste capable of retaining flexibility between minus 40°C to + 100°C (e.g. MAS 35).

5.2.2 **Jacketing Material**

Jacketing material on insulation on all pipes and equipment shall be of GI sheet of minimum thickness 0.71 mm, drawing quality, coating grade 250 or better conforming to specification IS: 277.

For cold (anti-condensation) removable type insulation jacketing material on equipment, valves and flanges shall be at least 0.91 mm thick GI sheet.

Non-removable type of cold (anti-condensation) insulation: In-situ applied polyurethane insulation cladded with galvanised steel cladding would be the preferred arrangement for such duty.

5.2.3 **Ancillaries:**

Wire Netting: Galvanized chicken wire netting of commercial quality of size 12.5 mm x 0.71 mm hexagonal construction shall be used.

Lacing wire: Soft, annealed G.I. lacing wire of minimum diameter of 0.80 mm shall be used.

Screws: Self tapping, rust proof screws shall be used for lap joints along with EPDM washers if needed.

Steel Bands: Galvanised steel bands of min. 12 mm wide x 0.5 mm thick shall be used for securing insulation.

Metal rods, clips and other supports for insulation except materials which are to be welded to pipes, equipment and ducting to provide support for the insulation.

For cleaning stainless steel surfaces, only acetone or superior kerosene with a free chloride not exceeding 25 ppm shall be used. All the cleaning agents shall be subject to the approval by the purchaser.

Epoxy paints e.g. Epilux-5 (Base & Catalyst) paint manufactured by M/s. Berger Paints (India) Ltd or Equivalent.

The Contractor shall arrange for suitable material and tools required for cleaning the surface to be insulated.

Only approved water proofing compound (MAS 94 OR EQV) shall be used for sealing the GI jacketing at the outdoor locations.

5.3 Materials Provided By Purchaser

All materials to be welded to pipes, equipment and ducting to provide support for the insulation if required, will be supplied and welded by the Purchaser. The locations shall be marked, on the surfaces to be insulated by the Contractor and approved by the Purchaser.

6.0 INSULATION THICKNESS

The insulation thickness, indicated in the schedule of quantities and rates given in the tender document shall be provided by the Contractor. However, preference will be given to the insulation materials having lower thermal conductivity (K value) and the materials involving easier application and maintenance.

The basis for selection of insulation thicknesses of various operating temperatures and piping and equipment are given in Tables A and B. The insulation thickness given in Table A are for hot insulation and Table B is for cold insulation. Insulation thickness can be modified subject to approval of Purchaser, if alternate insulation material is adopted with lower thermal conductivity.

TABLE-A

Insulation thickness (in mm) for hot insulation

Pipe Size N.B. (mm)	*Fluid Temperature (Deg. C)*				
	Up to 100	*101 to 150*	*151 to 200*	*201 to 250*	*251 to 310*
15	25	25	40	50	60
20	25	25	40	50	60
25	25	25	40	50	70
32	25	30	40	60	70
40	25	30	40	60	70
50	25	30	50	60	80
65	25	30	50	60	80
80	25	40	50	70	80
100	25	40	50	70	90
125	25	40	60	70	90
150	25	40	60	80	100
200	25	40	60	80	100
250	25	40	60	80	110
300	25	40	60	90	110
350	25	40	60	90	110
400	25	40	70	90	120
450	25	40	70	90	120
500	25	40	70	90	120
550	25	50	70	90	120
600	25	50	70	90	120
> 600 & Equipment, flat surface.	25	50	70	90	120

Insulation thickness given in Table-A has been calculated based on the following parameters.

Ambient temperature	35°C
Surface temperature	50°C
Wind velocity	0 m/s.
Emissivity	0.60 (for GI Cladding)
Material	Mineral wool Mats. 150 kg/m^3

TABLE-B

Insulation thickness (in mm) for cold insulation

Pipe Size N.B. (mm)	*Fluid Temperature (Deg. C)*			
	Up to 20	*20 to 11*	*10 to 0*	*-1 to -10*
15	25	25	35	40
20	25	30	35	45
25	25	30	40	45
32	25	30	40	50
40	25	30	40	50
50	25	35	45	50
65	25	35	45	55
80	25	35	45	55
100	25	35	50	60
125	25	40	50	60
150	25	40	50	65
200	25	40	55	65
250	25	40	55	70
300	25	40	55	70
350	25	45	60	70
400	25	45	60	75
450	30	45	60	75
500	30	45	60	75
550	30	45	60	75
600	30	45	60	75
> 600 & Equipment, flat surface.	30	45	60	80

Insulation thickness given in Table-B has been calculated based on the following parameters.

Ambient temperature	35°C
Relative humidity	85%
Surface temperature	32°C
Wind Velocity	0 m/s.
Emissivity	0.60 (for GI cladding)
Material	Polyurethane foam

7.0 APPLICATION PROCEDURE

Some important features of application procedure for insulation and other related items outlined in this specification are for the guidance of the Contractor. Detailed Method Statement for each type of job along with proposed Quality Plan shall be prepared by the contractor and shall be submitted along with the bid. The

above documents require approval of the Purchaser before commencement of any insulation work at site.

7.1 Application Procedure for Preformed / Cast in-situ Rigid Polyurethane:

Application and finishing of this insulation material, where used for low temperature anti-condensation insulation of cold carbon steel piping, G.I. ducting and cold stainless steel piping and equipment covered under clauses 4.1 & 4.2 of this specification respectively, shall be in accordance with IS:14164.

Polyurethane insulation shall fully meet the requirements of clause 5.1.1

Application and finishing of in-situ polyurethane work shall be in accordance with IS: 13205 specifications. Material properties when checked on a representative sample of foam drawn at site shall meet the requirements of IS: 14164.

7.1.1 Application Procedure for Carbon Steel Pipes & Equipment & G.I & C.S. Ducting Non-Removable Type of Insulation with pre-formed Polyurethane

(i) Surface to be insulated shall be cleaned and dried thoroughly.

(ii) A coat of cold sticker (Refer clause 5.2.1 of this Specification) shall be applied as per manufacturer's specification on the surfaces to be insulated and on the inside surfaces and edges of all polyurethane sections for proper adhesion, seal and cushion against vibration. The sections shall be struck on tightly and joints shall be sealed with cold sticker properly. Securement of insulation shall be carried out using aluminium bands 24 SWG x 12 mm wide at centre to centre distance of 300 mm.

(iii) The insulation sections of insulation shall be pre-cast or cut and carved with suitable tools.

(iv) Insulation of 60 mm and larger thickness shall be applied in multilayer construction with staggered joints. Between successive layers of insulation a coat of sealant as per 5.2.1.3 as applicable shall be applied for proper adhesion and sealing of joints.

(v) For very low temperature pipes operating at minus 20°C or below, a contraction gap of 15 mm shall be provided at every 6 metres filled tightly using 40 mm thick annular cuts of resin bonded mineral wool slabs, compressed to 15 mm.

(vi) All gaps between polyurethane sections / blocks shall be filled with joint sealant.

(vii) Pre-formed polyurethane blocks / pipe sections of minimum 120 kg/m^3 density shall be used at pipe supports or hangers that are on the outside of insulation on the 40 mm or larger diameter pipes. (For all such supports or hangers on all pipe

sizes, metal cradles 3 mm thick x 100 mm wide shall be fitted on the final covering by the Purchaser).

(viii) Wherever, a nozzle is connected to an un-insulated line, insulation shall not extend over the nozzle. Lugs, cradles, steel beams or skirts that are directly on the pipe or equipment, shall be considered to form a part of the item to be insulated. They will receive the same insulation thickness as specified for the body of the vessel and the insulation will be carried out in such a manner that the temperature of the adjacent non-insulated surfaces of the supports will not be lower than the dew point. This length will be decided by the Purchaser.

(ix) Vapour barrier for insulation with preformed polyurethane shall consist of two coats of approved mastic (e.g. MAS 131) with open weave glass cloth (10 x 10 mesh) provided between the two coats therein, for reinforcement.

(x) Pipe hangers and clamps shall be covered with vapour barrier mastic along with the pipe. The Contractor shall take care that the threaded portion of the clamps are not covered with the insulation.

(xi) For vertical piping, M.S. Collars with the outstanding projection from bare surface not exceeding 70% of the thickness of insulation shall be spaced at not over 2.0 M from each other.

(xii) Jacketing, where specified shall be with galvanised steel sheet, duly grooved and lapped with a minimum overlap of 50 mm.

(xiii) Bitumen and bituminous products shall not be used in any indoor applications.

7.1.2 Application Procedure for Carbon Steel pipes & Equipment Non-Removable Type of Insulation with Cast in-situ Polyurethane

A. Surface Preparation

The surface of piping to be insulated is wire brushed, and given a coating of Polyurethane – compatible paint.

B. PU Preparation

Polyurethane foam Insulation is a mixture of two component, component – A Polyol blend & component B ***Methyl Diisocynate*** (MDI). Component A is a mixture of polyol flame retardant, catalyst and 141-B (blowing agent). The proportions of these chemicals shall be as specified by the PU-chemicals manufacturer to achieve desired properties of PUF insulation. Foaming reaction takes place after mixing component A & component B, and full foaming of PU mix is achieved by vaporisation of mixed foaming agent into tiny vapour pockets in the insulation matrix.

C. Application

1. Cut spacer rings 50 mm wide of the same diameter and thickness of the insulation to be provided from slabs or preformed sections of polyurethane.
2. Apply adhesive and fix the above spacer rings at a spacing of 850 mm from each other (typical.)
3. Secure and tighten the spacer rings using GI bands 12 mm wide x 0.5 mm thick.
4. Fabricate cladding of specified thickness with grooves and beads. Cladding shall be lapped to 50 mm (min) and fitted tight with joint sealant applied at all joints.
5. Fix cladding on the spacers using specified overlaps and screw spacing. Joints to be provided with butyl rubber tape.
6. Drill pour and riser holes and inject metered quantity of polyurethane chemical mixture.
7. Tape off pour and riser holes.
8. Cut, trim and apply MAS 35 mastic or equivalent on pour holes.

7.1.3 Application Procedure for Removable Box Type Insulation for Carbon Steel Valves, Flanges and Equipment

(i) The adjacent pipe insulation shall be lap joint and finished, with mastic vapour barrier and cladding as per this specification. Clean and apply a layer of anti corrosive paint or aluminium foil faced mineral wool insulation, 25 mm thick to cover the entire surface, including the bare part of the adjoining pipe.

(ii) Provide and fix external cladding as required, maintaining a gap equal to the insulation thickness all around. This is achieved by use of spacers of preformed polyurethane. This cover is in two halves, with a parting plane along the vertical centre line of valve or flange. The entire inner surface of this fabricated cover is coated with a release coating of soft wax. This assembly is now ready for pouring of polyurethane chemicals to form the insulation.

(iii) Drill pour holes for chemicals and also vent holes for exit of air contained within. Polyurethane chemicals, in correct proportion are injected into the enclosure in metered quantity.

(iv) When the polyurethane is fully set, the external cover is removed slowly. The release agent on the inner surface would prevent adhesion to cladding and a clean block of polyurethane would be seen.

(v) Using a sharp cutter, insulation is cut neatly along the parting plane to result in two halves.

(vi) Mastic sealer and vapour barrier are applied as specified in 5.2. The cladding is replaced and fitted, closing all points for possible water entry.

The valves glands shall not be insulated.

For removable insulation on valves, flanges and equipment, proper care shall be taken to maintain continuity of the vapour seal between the fixed and the removable type of insulation.

7.1.4 Application Procedure for Stainless Steel Piping and Equipment

The insulation procedure for stainless steel piping and equipment (Clause 3.2) shall be the same as specified in clause 7.1.1 and 7.1.2 for carbon steel piping and equipment except for the clause 7.1.1 (i) for cleaning of surfaces to be insulated.

For cleaning of stainless steel surfaces, acetone or superior kerosene with chloride contents not exceeding 25 ppm shall be used.

After cleaning, the surfaces shall be painted with at least two coats of Epilux-5 manufactured by M/s. Berger Paints (India) Ltd. or equivalent (base & catalyst) and dried. Alternatively, Aluminium foil, 0.10 mm thick is wrapped carefully on bare pipe, ensuring that there are no points for water entry from the insulation system to the bare pipe / equipment. Protection of SS surfaces to be insulated requires careful workmanship and close supervision.

On the painted and dried surfaces, the insulation procedure shall be same as for cold carbon steel piping and equipment (removable and non-removable types).

7.2 Application Procedure for Bonded Mineral Wool

7.2.1 Application Procedure for Bonded Mineral Wool Mattresses

7.2.1.1 **General Requirement**:

This material can be used for thermal insulation of hot carbon steel and stainless steel piping and equipment specified under the clause 4.3, 4.4 & 4.5. Application and finishing of thermal insulation shall be in accordance with IS:14164.

Bonded mineral wool mattresses shall fully meet the requirements of clause 5.1.2 and 5.1.3.

Surfaces of pipes, ducts and equipment shall be thoroughly cleaned and dried.

Bonded mineral wool and mattresses for large diameter piping and equipment shall be used as far as practicable. On lines requiring more than 80 mm insulation, the insulation shall be applied in two or more layers. All joints shall be staggered and the inner layer shall have minimum 50 mm thickness. All gaps shall be densely filled with loose mineral wool.

The mineral wool mattresses to be used shall have a soluble chloride content of less than 25 ppm. Stainless steel lines shall be covered with a layer of aluminium foil of thickness of 0.1 mm before application of insulating materials. A minimum overlap of 50 mm shall be maintained and the work shall be carried out with careful workmanship and close supervision.

7.2.1.2 All pipes and equipment shall have suitable supports, which provide for sufficient space around piping for required thickness of insulation and jacketing.

On continuous runs of 6 M or more of vertical pipes and vessels, support rings shall be provided at not more than 3 meter intervals. Such ring shall encircle the pipe and the radial lugs thereon shall have a length equal to 75 percent of the total insulation thickness. (Refer Sketch-III).

Insulation at the support shall be jacketed with G. I. sheets of 0.6 mm thickness. Fastening shall be with pan head self tapping screws, size No 8, 12 or 18 mm long. Spacing of screws shall be suitable for close fit-up, but not over 150 mm.

7.2.1.3 The insulation on valves and flanges shall be covered with removable GI boxes using 0.91 mm thick GI sheet. (Refer Sketch IV).

7.2.1.4 Expansion joints shall always be insulated with mineral wool mats (IS: 8183). However, the convolution shall first be wrapped with minimum 0.1 mm aluminium foil to allow free expansion and contraction of pipes.

7.2.2 **Application Procedure for Pre-formed Mineral Wool Pipe Sections and Resin Bonded Mineral Wool Slabs Insulation on Pipes and Equipment**

For insulation of piping and equipment, preformed sections tested in accordance with IS: 9842, shall be neatly applied with all edges tight butted. Where gaps are un-avoidable in longitudinal or circumferential joints, a strip of bonded mineral wool insulation shall be used to fill such gaps. On multiple layers of insulation, both longitudinal and circumferential joints of outer layers shall be staggered with respect to those of inner layers.

For piping, each layer of insulation shall be secured firmly in place with galvanised, annealed steel binding wire using not less than 3 loops of wire per metre length of insulation on pipe size up to 200 mm inclusive. The twisted ends of the wire shall be embedded in the insulation in all cases. On piping above 200 mm diameter, 12 mm x 0.5 mm thick stainless steel bands shall be used for securing the insulation.

All pipes and equipment shall have suitable supports for insulation and jacketing.

Insulation sections / slabs shall be suitably cut to give a proper fit up on pipe fittings, valves and flanges. The blocks shall be secured firmly in place with annealed G.I. Wire or stainless steel bands. Gaps and irregularities of joints shall be filled by strip of bonded mineral wool insulation and smoothened by suitable insulating cement approved by Purchaser. Valves, fittings and flanges of 250 mm and larger sizes shall have a covering of 12.5 mm x 0.71 mm hexagonal galvanised annealed steel wire mesh.

For equipment each layer of insulation shall be secured firmly with 12 mm x 0.5 mm stainless steel band at 300 mm centre to centre. On top of the final layer of insulation 12.5 mm x 0.71 mm hexagonal galvanized annealed wire mesh be tightly fixed. A levelling coat of insulating cement shall be applied over the wire mesh. Layer of wire netting and levelling coat of cement are not needed for resin bonded mineral wool.

For all insulation cladding systems, GI sheets of minimum 0.71 mm thickness shall be used for jacketing with self-tapping screws.

Removable parts of equipment, flanges, valves and name plates shall be covered with removable type insulation with 0.91 mm cladding thickness.

7.2.3 Application Procedure for Sprayed Mineral Wool:

Alternatively, spray mineral wool may be preferred wherever possible (IS: 9742). Application procedure shall be as per IS 12432 part 1. Actual method to be employed as recommended by manufacturer shall be submitted to Purchaser by the Contractor for approval.

7.3 **Application Procedure for Calcium Silicate**

These insulation materials shall be used for the turbine and associated equipment, where specified, covered under clause 4.4 except for the insulation of reheaters and expansion joints.

The material shall fully conform to the requirements of clause 5.1.4.

All surfaces shall be thoroughly cleaned and dried. The material shall be applied as pre-formed blocks on equipment of regular shape as quoted by the Contractor. For the equipment of irregular shapes, the material shall be applied in the form of wet cement. Only pre-formed pipe sections shall be applied on piping. Fire resistant paint shall be applied over the insulated surface to prevent the oil soaking if any slippage is there.

7.4 **Application Procedure for wet cement**

This procedure shall be applicable for the insulation of turbine and associated equipment other than reheaters and expansion joints covered under clause 4.4. The above can also be used for the insulation of equipment with irregular surfaces, where use of pre-formed blocks is not possible. The cement shall be tested in accordance with IS: 5724.

7.4.1 The Contractor shall mark the locations of the studs to be welded on the equipment to be insulated. It is Purchaser's responsibility to get the studs welded on the equipment accordingly.

7.4.2 Dry powder shall be mixed with suitable quantity of halide free water and the wet cement shall be applied manually. The surfaces to be insulated shall be coated with a suitable primer for the proper adhesion of the first layer of insulation.

7.4.3 Over every 50 mm thick insulation, one layer of chicken wire mesh shall be fixed. Previous layer shall be thoroughly dried before applying the next layer. When final insulation thickness is built up, studs (welded by the Purchaser on the equipment surface) shall be ***bent*** into the insulation and 12 mm thick layer of suitable insulating cement approved by the Purchaser shall be used to smoothen the surface.

7.4.4 When no cracks are observed after drying, the top surface shall be jacketed with GI sheets (minimum 0.71 mm thick) with self tapping screws.

7.5 **Equipments/Piping under In-Service Inspection (ISI)** ***and inspections on account of FAC- flow accelerated corrosion.***

7.5.1 Some circumferential weld joints for some of the piping and equipments (viz. steam generator pressurisor, bleed condenser etc.) are required to be subjected to periodical in-service inspection. All piping, piping components, equipments, equipment nozzles which are to be examined as per FAC inspection program shall also have removable type of insulation. Removable insulation for piping, valves, flanges are suggested below in sub para 7.5.1.1 & 7.5.1.2. However, contractor may suggest suitable insulation at such location (including inspection area) which can be easily removed and installed back with proper sealing of joints. Metal encapsulated Insulation removable types are to be provided on all circumferential joints like that of SG & pressurisor. Drawing for the same shall be submitted by vendor.

7.5.1.1 **Provisions on Removable Pipe Insulation for Welded Joints Intended for PSI / ISI/ Inspection for flow assisted corrosion (FAC) of piping & piping component.**

All removable insulation shall be fabricated with outer envelop of 0.91 mm thick GI sheet, constructed generally as per enclosed Sketch-I. Internal insulation shall be mineral wool pipe sections or light resin bonded flexible mats encased fully with close weave glass fabric (7 mil thick). Removable insulation block shall be mechanically fixed to outer cover for all pipe sizes to ensure that the assembly can be removed and refitted easily in two halves. Latch and buckles shall be provided to secure the halves together tightly. The metal cladding shall have an extended overlap length on each side to ensure that the removable insulation section is seated properly and cladding joint gets sealed to the cladding on the line insulation against ingress of water / oil etc. The length of such section shall be 300 mm or more such that adequate pipe surface is available on both side of weld joint during PSI/ ISI. In case of all such components/piping/equipments identified for examination as per FAC inspection program, removable insulation shall be provided such that they are available for inspection.

7.5.1.2 **Removable Type Insulation on Valves & Flanges Etc. of Pipe Lines & Equipments**

Thermal insulation (Box type) on all the pipe flanges, valves and online equipments coming on piping and equipments shall be done. Typical sketches are enclosed (Refer sketch-V & VI*). Sketch V is for NB ≤ 80 mm, while sketch V(a) is for valve > 80 NB.*

7.5.2 Some heat exchangers required periodic ISI of tubes. Channel covers of such equipments shall be suitably insulated to allow easy removal and installation of

channel covers without removal of insulation alone. In such locations removable metal encapsulated insulation can be provided.

7.6 Insulation of Boiler Feed Pumps and Reheaters :

Boiler feed pumps (Clause 4.3) and reheaters (Clause 4.4) shall be insulated by preparing and fixing of 50 mm thick mineral wool blanket backed on both sides with close twill weave glass fibre cloth and stitched with glass thread, binding wire and then GI jacketing in the form of a box shall be used on the bags.

7.7 Provision on Insulated Pipes for Areas Prone to Inadvertent Foot Step Loading

Insulated pipe lines / equipments are not be used as platforms as it may damage the insulation. Suitable provision like cross over platforms are to be provided across insulated pipe lines which come in passage of personnel / material movement, wherever required. However, pipe lines which are located at grade level or close to high maintenance areas are vulnerable to inadvertent foot step loading during construction, commissioning, operation and maintenance. For such areas, arrangement as shown in the enclosed sketch-II (indicative) may be followed after reviewing the loading / requirement of individual area.

Irrespective to the insulation material used, double end (Z Shape) spacer rings constructed of 30 mm x 3 mm thick galvanized flats shall be provided at spacing not over 425 mm from each other. These spacer rings may be constructed with "Supercera thermal breaks" or equivalent to prevent direct conduction. After application of insulation as per design requirement, a cap plate of 1 mm thickness shall be provided over the top 120 degree of the pipe circumference. This additional cap plate will be pop riveted to the spacer ring as shown in sketch-II. Normal metal cladding shall be provided on the top of this arrangement as per this specification.

7.8 Additional Provisions on all Insulated areas which are Vulnerable to Oil Drips from Lubrication System / Hydraulic System etc.

In such areas, after provision of all elements of the insulation design and prior to provision of metal cladding, an impermeable barrier of supercera fabric (or equivalent) laminated to aluminium foil shall be wrapped around, with all edges stitched and sealed with self adhesive aluminium foil tape 75 mm wide, so that oil does not get soaked in insulation. Metal cladding shall be carried out on the top of above barrier treatment. It is to be ensured that lap joint sealant MAS 94 or equivalent is provided at all the metal joints to prevent oil ingress in the insulation

system. Mock-up shall be carried out to establish the procedure at site and report shall be issued to Purchaser.

7.9 Insulation of Feeder and Header Insulation Cabinet (FHIC) :

Insulation of feeder and header insulation cabinet is of panel type. Due to the space limitation in the area of feeders and header, it is difficult to insulate all individual components, and hence cabinet type arrangement is provided. Mineral wool mattresses sandwiched between Galvanized sheets shall be used to make the panels.

- There are penetrations in the various faces of the cabinet like :

  - Feeder supports are penetrating from lower rear face and top central face of the cabinet.
  - RTD cables, flow monitoring tubes, DN monitoring tubes are penetrating from the upper front face of the insulation cabinet.
  - End shield cooling pipe lines are penetrating from the bottom face of the insulation cabinet.
  - Header outlets are penetrating from top face of the insulation cabinet.
  - Annulus gas monitoring tubes are penetrating from the east and west face of the cabinet.
  - Part of the coolant channel end fittings is penetrating from the lower front face of the insulation cabinet etc.

  Details of all these penetrations are given in the respective drawings. The insulation arrangement shall seal all these opening perfectly, so that there shall not be any chance of air/heat leakage from the insulation cabinet.

- Drawings given along with the tender document specifies the space available for installation of the insulation cabinet and penetration through it.

  Due to the lack of space for certain faces of the FHIC, wherever insulation thickness is less than specification requirements, Microporous insulation may be considered. For installation of FHIC, the technical specification for FHIC shall be followed.

  Skirt arrangement for RIH/ROH nozzle (typical) to avoid ingress to F/H insulation Cabinet is shown in sketch VII.

7.10 Typical Detail for Insulation Box for C& I Tappings meant for TG/TE/ME on pipelines.

Whenever maintenance of C & I Instruments such as TG/TE/ME on pipe lines is required, entire panel of part of the concerned pipeline is required to be removed and afterwards same panel is to be reinstalled. This involves lot of work and effort by several agencies.

A modified arrangement of insulation shall be implemented in such a way that a small box (200 x 200) shall be provided (in 2 halves) at all thermowells meant for above C & I instruments. Also whereever C & I tappings are emanating the axial length of the insulation panel shall be kept small (around 300) so that if required only a small panel is removed later on during maintenance. This modified arrangement is required as an improvement to ensure ease of maintenance. A typical arrangement of above said box is enclosed as Sketch IX & X.

7.11 Typical arrangement for Heat Exchangers (Shut down HX, Secondary side HXs and other HXs requiring Inservice Inspection is shown in Sketch VIII.

For Sheet Metal Encapsulated Thermal Local Insulation systems for Steam Generators is covered in specification PP – E – 1156.

7.12 In general all pumps shall be insulated by using removable type of insulation from mineral wool. Due to irregular surface, if mineral wool cannot be used, in such cases calcium silicate shall be applied.

8.0 EXAMINATION AND TESTING

8.1 All materials required for thermal insulation, including jacketing and other finishing materials shall be new and subject to the approval of the Purchaser.

8.2 All the insulation material received at the plant site shall be stored in the batches properly identified. The Quality Plan (QAP) for material shall be submitted for approval of Purchaser prior to commencement of work. All test certificates providing the proof of the requirements shall be provided for each batch as per approved QAP. Purchaser has the right to ask for additional testing at no extra cost in order to satisfy himself, that the insulating materials fully meet the requirements of clause 5.1.

8.3 The application of the insulation and finishing of the insulation work shall be of first class workmanship subject to the approval of the Purchaser.

8.4 In case of wet cement insulation, the Contractor shall specify the proportion of various ingredients to be used for the mix. The insulation thus obtained shall fully meet the requirements of clause 5.1.4 of this specification and the same

proportions of ingredients shall be used throughout the job. Random sampling and testing may be asked for if deemed necessary.

9.0 QUALITY ASSURANCE PLAN (QAP)

The supplier shall submit a detailed QAP for approval by the Purchaser. Quality assurance plan for the work covered by this specification shall meet the minimum requirements of control and tests as given below. Final QAP as approved by the Purchaser shall be used during insulation erection/installation.

S.NO.	Description	Control and tests	Action by Supplier	Quality Surveillance by purchaser or his authorised representative
1	**PROCEDURES**	Submission of insulation application procedure, inspection and test procedure	Submission by Supplier	Approval by Purchaser
2	**MATERIALS**			
I	**MINERAL WOOL**	Density, Dimensions	I	R, C
		Recovery after compressive, moisture content & moisture absorption, thermal conductivity, irradiation resistance, chloride content, incombustibility	I	R
II	**POLYURETHENE**	Density, Dimensions	I	R, C
		Dimensional stability, moisture absorption, closed cell content, horizontal burning, thermal conductivity, compressive strength	I	R
III	**PREFORMED FIBREOUS INSULATION**	Density, Dimensions	I	R, C
		Thermal conductivity, chloride content, moisture content & moisture absorption test	I	R

IV	**GI SHEET (JACKETING MATERIAL)**	Tensile test, bend test, dimension, coating test	I	R, C
V	**INSULATION CEMENT**	Consistency of wet mixed thermal insulation cement, covering capacity and volume change upon drying of thermal insulation cement	I	R, C
V	**INSULATION CEMENT** **(continue from previous page)**	Compressive strength, thermal conductivity, linear shrinkage of preformed high temperature thermal insulation subjected to soaking heat, adhesion of dried thermal insulation cabinet	I	R
VI	**SPRAY MINERAL WOOL**	Density, dimensions	I	R, C
		Compressive strength, thermal conductivity, adhesion, heat resistance, incombustibility	I	R
VII	**CALCIUM SILICATE**	Density, dimensions	I	R, C
		Compressive strength, heat resistance, linear shrinkage, flexural strength, alkalinity, moisture content, chloride, thermal conductivity	I	R

3	**INSTALLATION**			
I	**GENERAL**	All insulation material is in close contact with the surface to which they are supplied	I	R, C
		Edges and ends of sections shall be join by lap joint. Close to one another over their whole surface except is special application described by Purchaser	I	R, C
		In multi layer insulations, all joints shall be staggered. Each layer shall be separately secured to the surface.	I	R, C
		Fittings on the equipments and vessels shall be covered with an independent insulation to allow easy access and removal without disturbing the main insulation.	I	R, C
		Suitable protective finish (e.g. finishing cement, sheet metal etc.) shall be applied over the insulation	I	R, C
		Before the insulation of fittings is taken up, insulation of the pipe with its protective finish shall be completed.	I	R, C
II	**SURFACE PREPARATION**	Before application of the insulation, surface shall be cleaned to remove all dirt, scale, oil etc. and dried.	I	R,C

		Clean surface shall be coated with anti corrosive paints, where ever specified by the Purchaser	I	R,C,H
III	**COLD SURFACE**	Each pipe shall be insulated separately	I	R, C
		Proper care shall be taken during application of cold sticker, vapour barrier	I	R, C,H
		Gap between insulation Section / Block shall be filled with joint sealant	I	R, C
		While applying multiplayer insulation, all joints shall be staggered. The final two layers shall be provided with adequate vapour barrier.	I	R
		Stiffener angles, weld protrusions, ladder supports, insulation support rings, pipe hangers or any metal connections shall be insulated if in direct contact with the cold surface. The insulation thickness over such protrusion shall have at least 50% of the thickness of the adjoining section	I	R

III	**COLD SURFACE (continue from previous page)**	Vapour seal material shall be applied all over the exposed edge of the insulation and bonded to the surface of pipe or vessel. At all such point's mastic fillet shall be provided to round off the angle between the insulation and the weld surface.	I	R, C
		Vapour seals on the fittings shall be carried over at least 50 mm beyond the finish vapour barrier of the main insulation system and sealed properly.	I	R, C
		Vapour sealing material shall be carried over expansion joints or contraction breaks without a joint	I	R, C

IV	**HOT SURFACE**	In case of jointly insulated pipelines, each pipe lines shall be insulated separately. This is to avoid the effect of differential expansion due to difference in temperature Stiffener angles, weld protrusions, ladder supports, insulation support rings, pipe hangers or any metal connections shall be insulated if in direct contact with hot surface. Thickness of the insulation on such protrusions shall be not less than 50% of thickness of the main system	I	R, C

Legend:

I : Complete action and inspection by supplier on a 100% basis.

R : Review of test records, test reports, procedures, test certificates, records of process parameters etc.

C : Checking the actual component or witnessing the inspection / testing activity on a suitable percentage / random basis

H : Hold point by Purchaser

10.0 QUALITY ASSRUANCE BY THE PURCHASER

10.1 All work covered by this specification shall be subject to quality surveillance by the purchaser or his authorised representative for which purpose the supplier shall:

a) allow access at all reasonable times during preparedness for installation / installation to :

- The premises in which the work is being carried out,

- The drawings and the tooling, wherever involved and
- Gauges, instruments etc. required for inspecting the work and

b) Produce an inspection and quality control plan to the purchaser's satisfaction and notify him when the check points on the plan are imminent so that purchaser's authorized quality surveillance representative can be present during salient intermediate stages of the job.

10.2 Inspection and tests shall be carried out as per the requirements of governing specifications.

10.3 Quality Surveillance by the Purchaser or his authorized representative shall not relieve the supplier from the responsibility of meeting the specification or the inspection duties called herein.

11.0 SUBMISSION OF TECHNICAL DOCUMENTATION

11.1 The following documents shall be submitted by the contractor with the bid.

- If alternate material is proposed, other than the specified material in the specification, justification of it with technical details shall be provided.
- Insulation application procedure in detail indicating step by step complete activities for each job.

11.2 The following documents shall be submitted by the contractor for approval by Purchaser after placement of the order and before taking up the job.

- Insulation application procedure in detail indicating step by step complete activities for each job.
- Quality control / detailed QAP and procedures indicating step by step complete quality control / inspection programme at all stages of each job.
- Inspection and test procedures.
- Marking, identification and packaging procedures, if any.

11.3 History Docket :

Contractors shall submit 5 copies of bound history docket containing ***atleast*** the following. The History Documents shall be approved by the Purchaser or his authorized representative. Soft copy of the history shall also be submitted.

1. Purchaser Order / Site Contract
2. Applicable Specification and Drawings
3. All approved application procedures, inspection, testing procedures, inspection plan / QAP.
4. All material test certificates, all other test and inspection reports.

5. Design concession requests if any.
6. Performance Guarantee Certificate.
7. Shipping release.

Approval of above technical documentation by purchaser shall not relieve the contractor from full responsibility for correct interpretation of purchaser's specifications and drawing and for the completeness and accuracy of contractor's technical documentation. It shall be the total responsibility of the contractor to ensure that the product supplied and installed is in accordance with the governing specifications.

12.0 OTHER REQUIREMENTS

12.1 Insulation work on piping and equipment shall only be done when the system has been completely tested and cleared for insulation work by the Purchaser.

12.2 The term cleaning used in the Specification means that the surfaces to be insulated shall be made free of all loose scale rust, grease, dust, oil or any other foreign matter. The surfaces thus cleaned shall be thoroughly dried before proceeding with any insulation work. The procedure for cleaning shall be subject to the approval of Purchaser.

12.3 Insulating material offered by the Supplier shall have a proven record of satisfactory service in Indian conditions for an acceptable period as outlined in the Tender Document. All insulation materials shall be rot-proof, vermin proof, chemically inert and shall not cause corrosion when applied on the metal surfaces.

12.4 The surface of GI jacketing in contact with insulating material on hot insulation shall be protected with approved primer against corrosion (Moisture barrier). For example TUFKOTE "ETCH PRIMER" from M/s. Shalimar Paints or Bison wash Primer from M/s. Burger Paint or Amerlock-400 from M/s. Goodlass Nerolac or equivalent.

12.5 Insulation shall be neatly applied with all edges tightly butted and joints shall be staggered. All joints and gaps shall be closely filled with the respective insulating material. Circumferential joints shall be at least 150 mm apart between layer and longitudinal joints shall coincide with the axis of pipes and equipment. Insulation subjected to vibration or/and thermal expansion and contraction shall be reinforced with additional supports and lacing.

12.6 The surface areas of equipment and running lengths of pipes to be insulated are estimated, in the schedule of quantities & rates in tender document only for the

guidance of the Bidders. However, the bidders shall make their own assessment, with the help of the drawings issued along with the tender.

12.7 Where roller type supports are specified on the outside of insulation of the piping, a suitable thickness of load bearing insulation like cellular glass of 150 mm length on either sided of the saddle size.

12.8 Insulation Contractor shall not carry out any welding on the piping or equipment.

12.9 The joints of GI jacketing shall be sealed with approved metal sealing compound (e.g., MAS-94).

12.10 In the case of steam feed water lines exposed to atmosphere, the longitudinal and circumferential joints of the jacketing material shall be sealed with a suitable compound (MAS-94) to prevent entry of rain water / moisture in the insulation. Wherever hanger supports are located, the gap between hanger support and line jacket shall be properly sealed to prevent entry of rain water along hanger rods / brackets. The procedure for sealing for the above shall be submitted for approval of Purchaser before taking up the work.

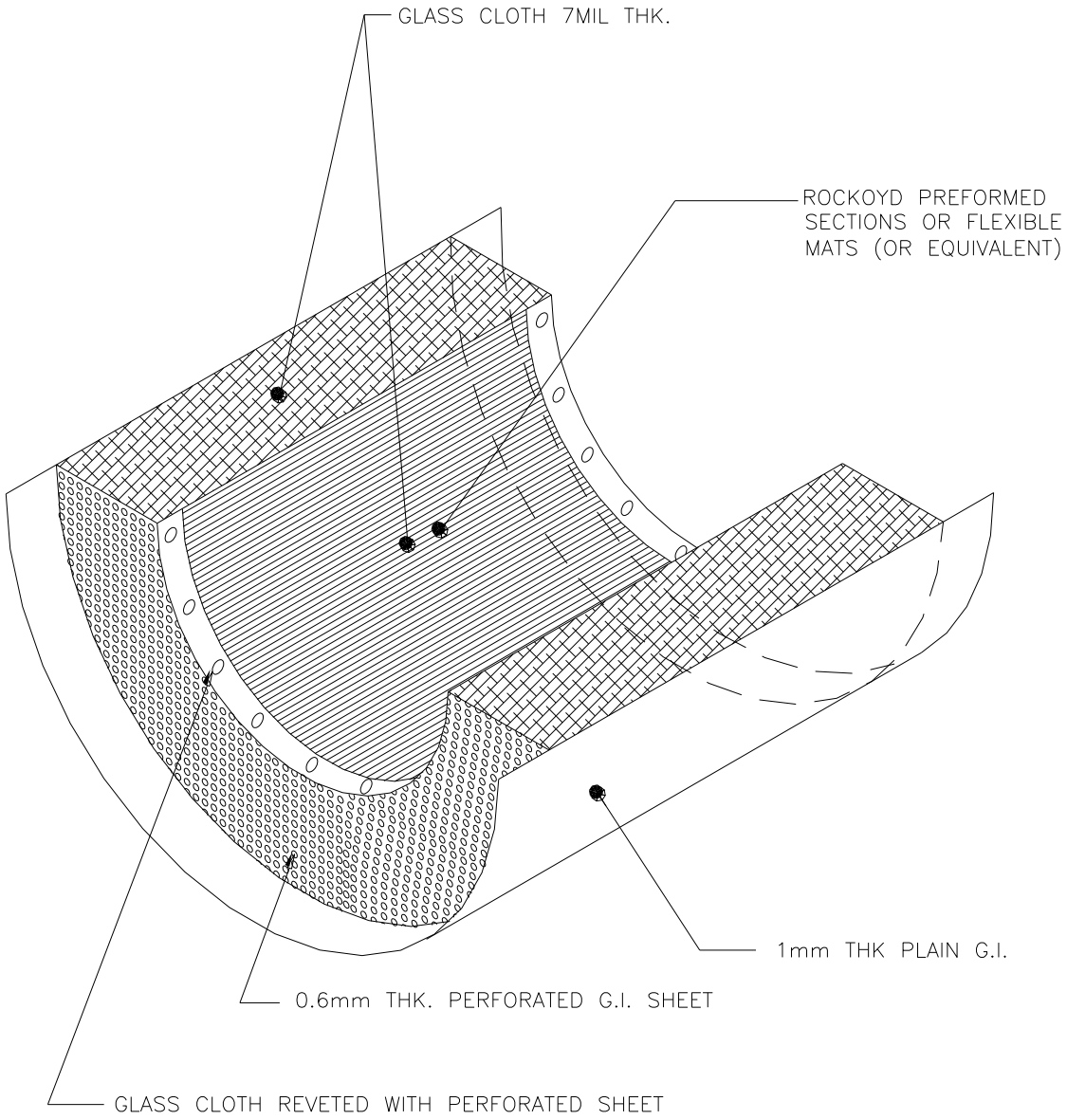
12.11 Weld joints below insulation over PHT system shall be marked suitably on the surface of insulation to facilitate locating weld joints for in service inspection. The Insulation for such joint shall be removable type (see sketch - I).

12.12 The sand cement used for plastering in the case of cold insulation shall be in the ratio of 1:3 with at least 2% by weight of CICO or IMPERMO.

12.13 Additional provisions on Cold Insulation of Pipe Lines:

All pipelines shall be insulated at support locations (sliding/guiding or anchor) featuring high density polyurethane pipe section blocks and secured to the footing using clamps designed for tight securement of the assembly to pipe. In order to ensure continuity of cladding all through these support locations, support assembly shall feature a short section of cladding interposed between the outer diameter of the High Density Support blocks and the external clamping. The cladding work for the line insulation shall start with a lap joint over these cladding sections as supports. Line insulation shall be carried out by in-situ polyurethane system using GUSMER (or equivalent) High pressure foaming machines operated by skilled operators..

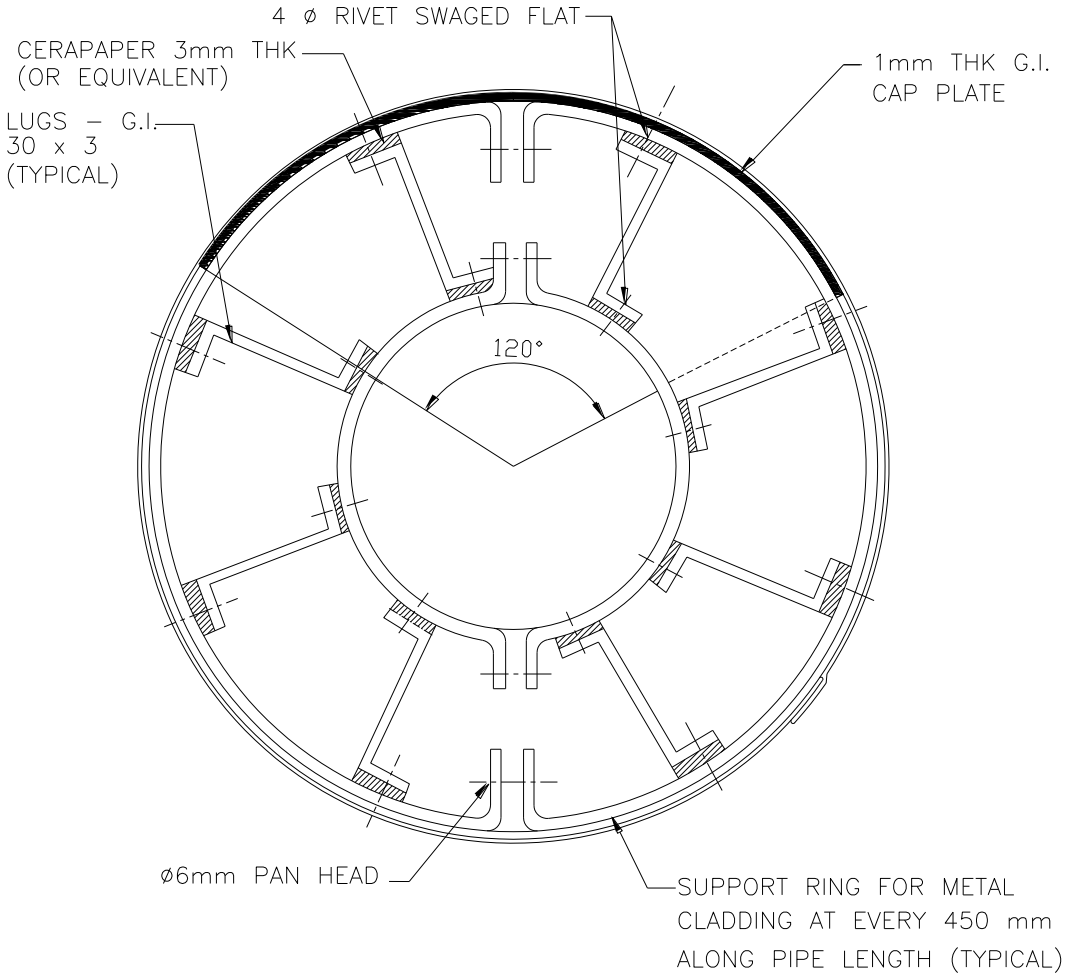
INSULATION DETAILS (TYPICAL) WELDED JOINTS INTENDED FOR PSI/ISI (INDICATIVE)



NOTES:– LATCH AND BUCKLES SHALL BE PROVIDED TO SECURE THE HALVES TOGETHER TIGHTLY.

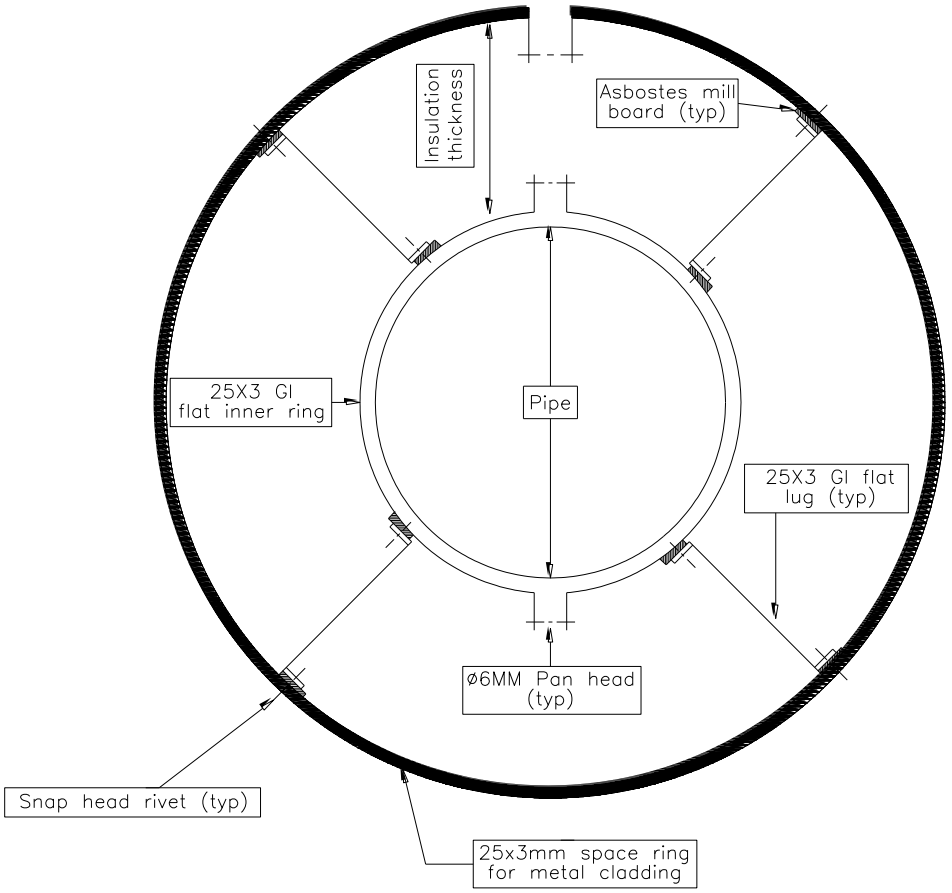
SKETCH – I

DETAILS (TYP) FOR INSULATION AREAS PRONE TO INADVERTENT FOOT STEP LOADING. (INDICATIVE)



SKETCH – II

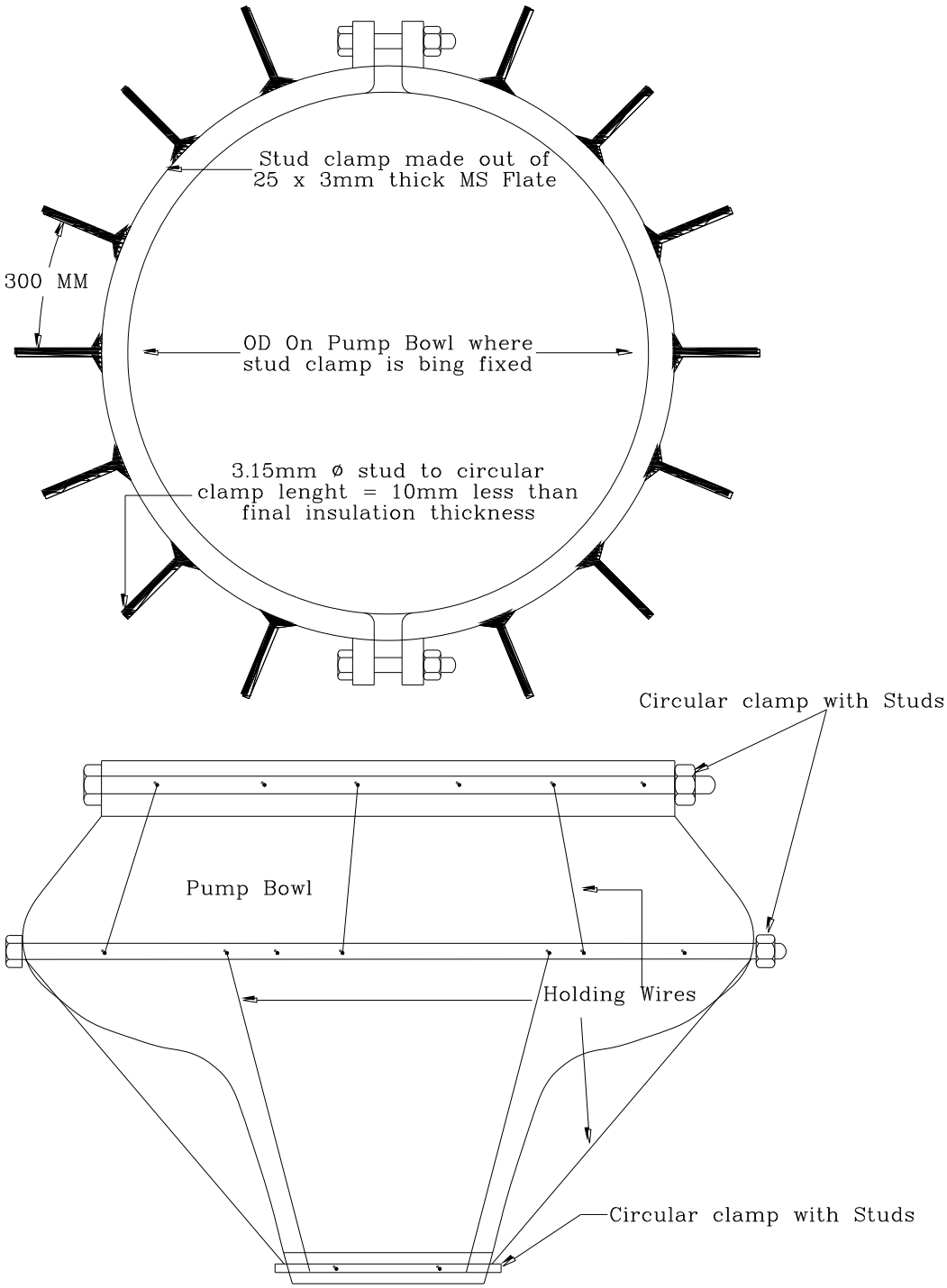
SKETCH OF SPACER RINGS TO BE PROVIDED DURING INSULATION
(SECTIONAL VIEW WITHOUT LAGGING)



NOTE :—
1.Actual Number of legs will be decided by contractor based on pipe size.
2.This skech is indicative and final drawing is to be prepared by contractor and approved by NPCIL.

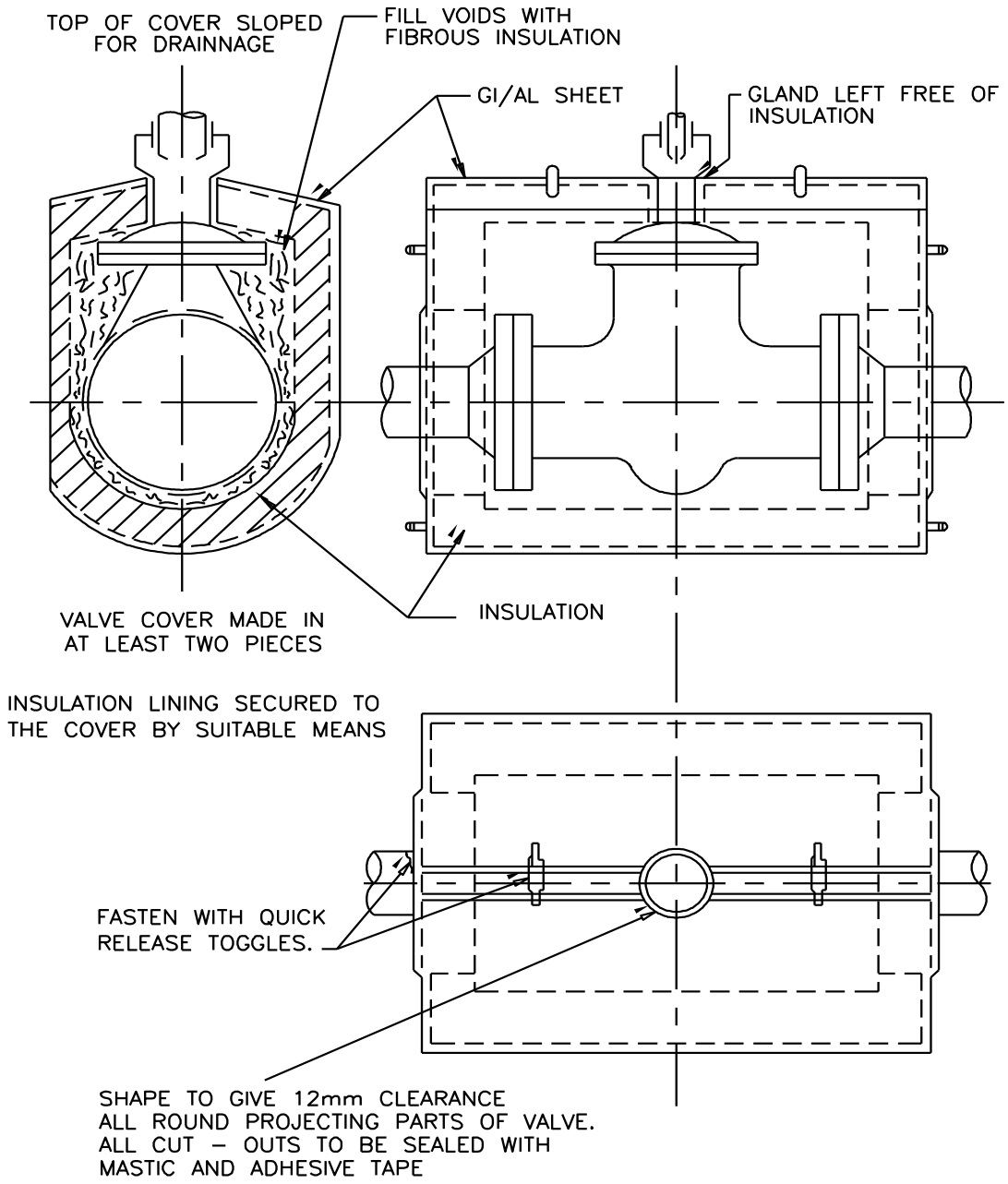
SKETCH – III

Typical Insulation Details For Pumps



SKETCH – IV

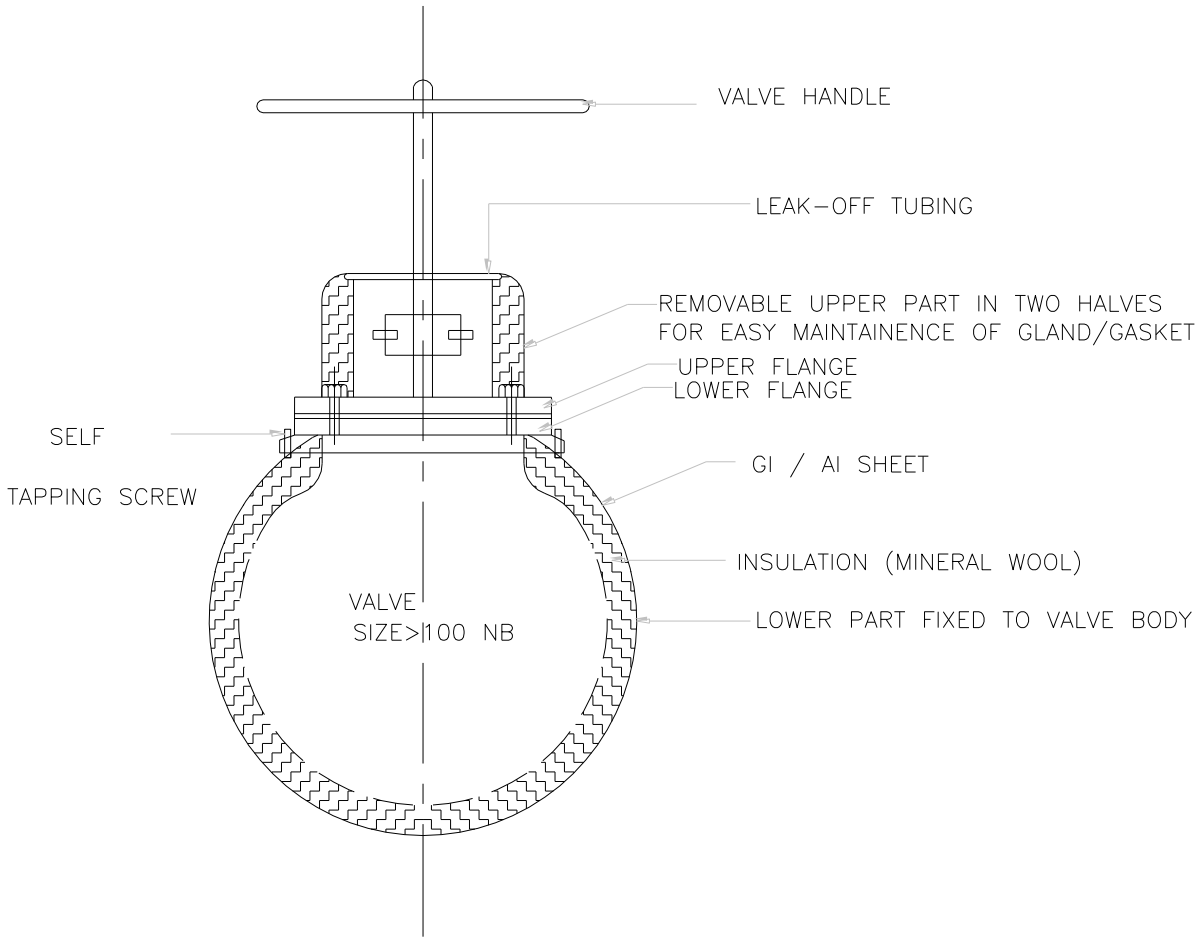
TYPICAL INSULATION DETAILS FOR VALVES ⩽ 80 NB



SKETCH – V

HOT INSULATION TYPICAL ARRANGEMENT

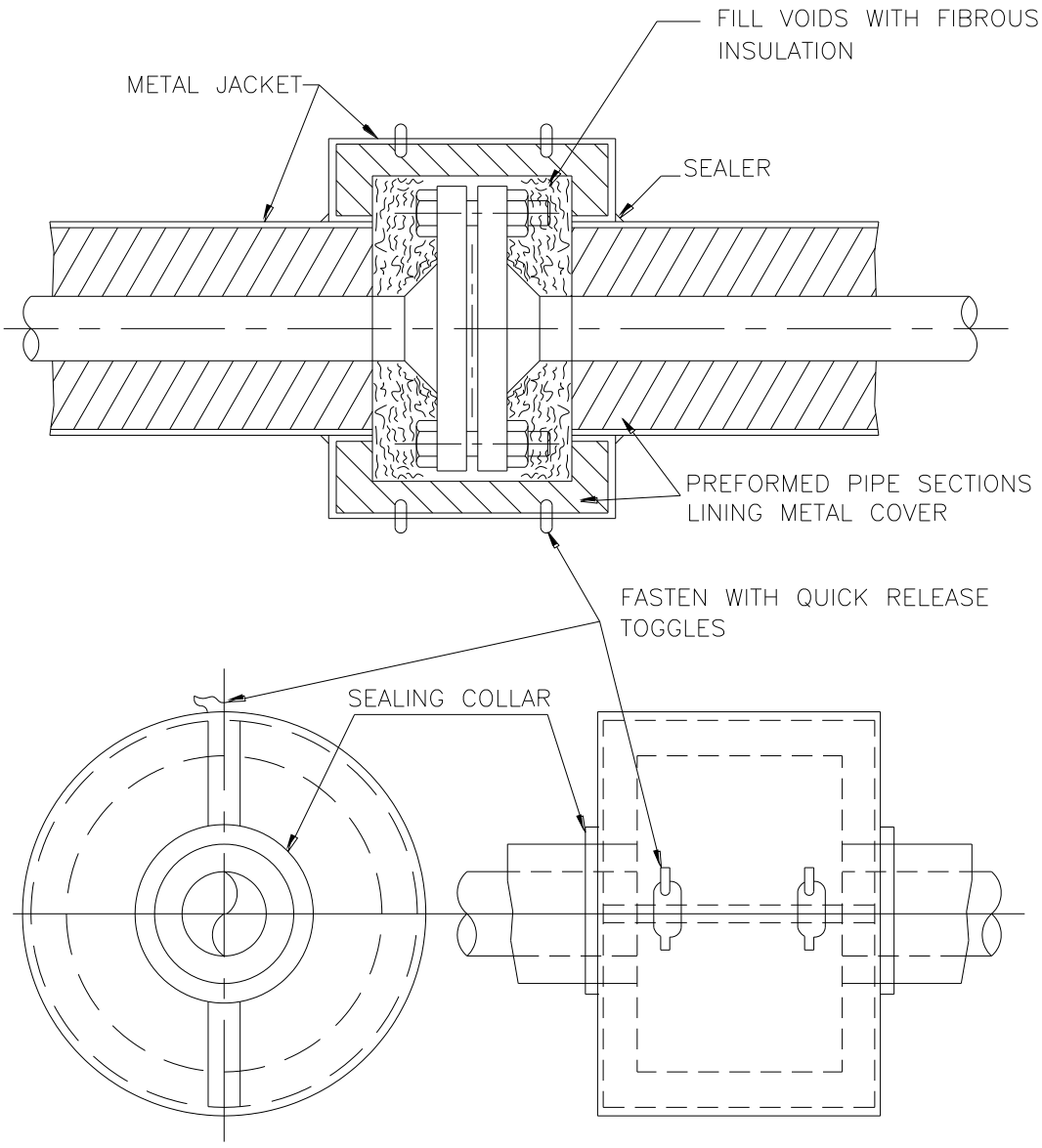
FOR VALVES >80 NB



SKETCH-V(a)

SUGGESTED INSULATION DETAILS

FOR FLANGED JOINTS/GRAYLOC JOINT



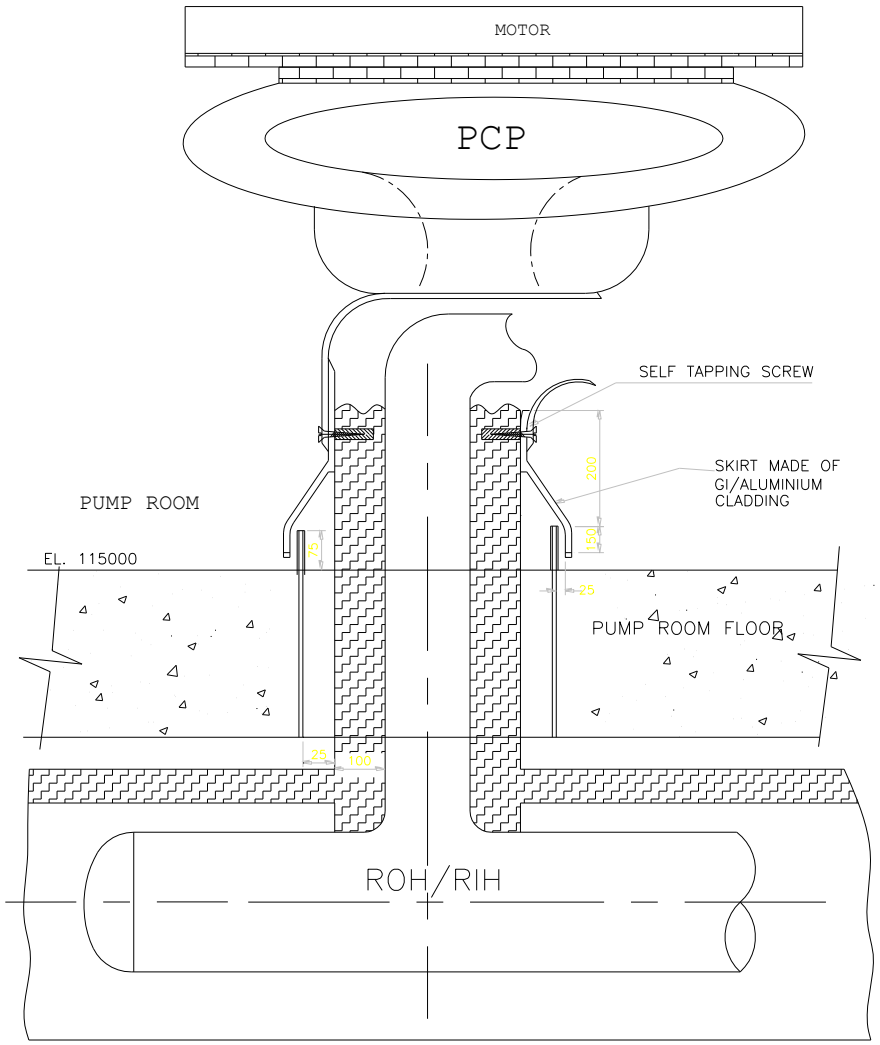
SKETCH – VI

SKIRT ARRANGEMENT

FOR RIH/ROH NOZZLE (TYPICAL) TO AVOID

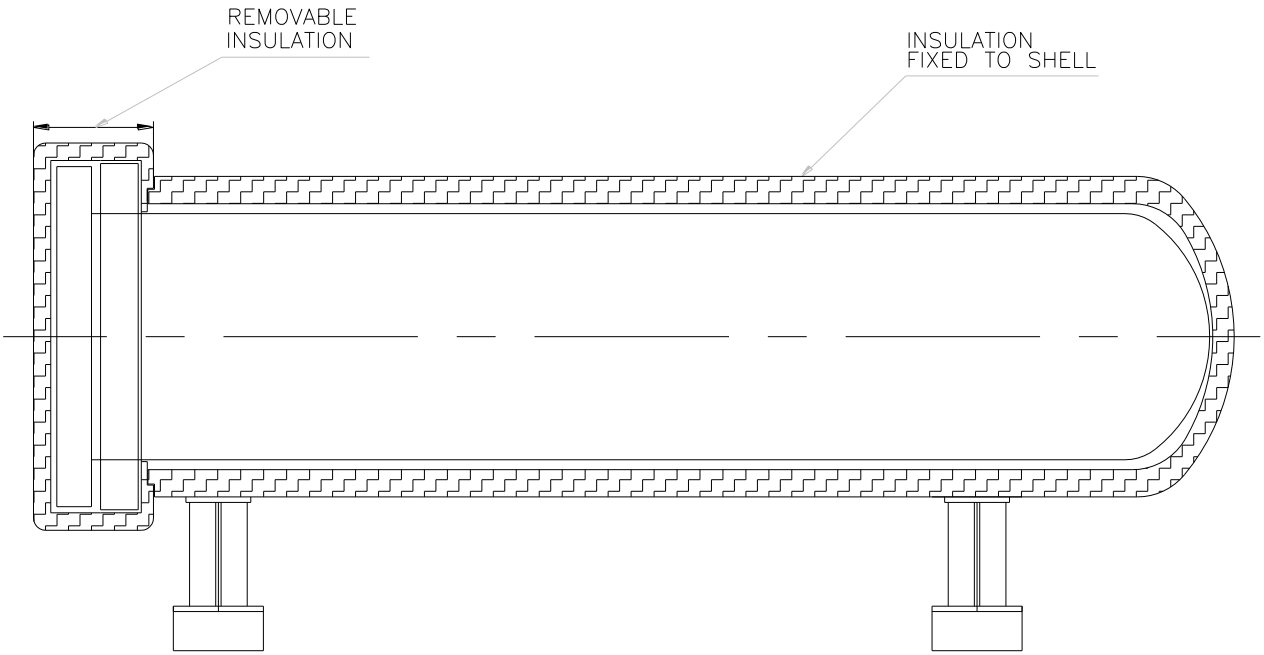
OIL INGRESS TO FEEDER & HEADER INSULATION

CABINET



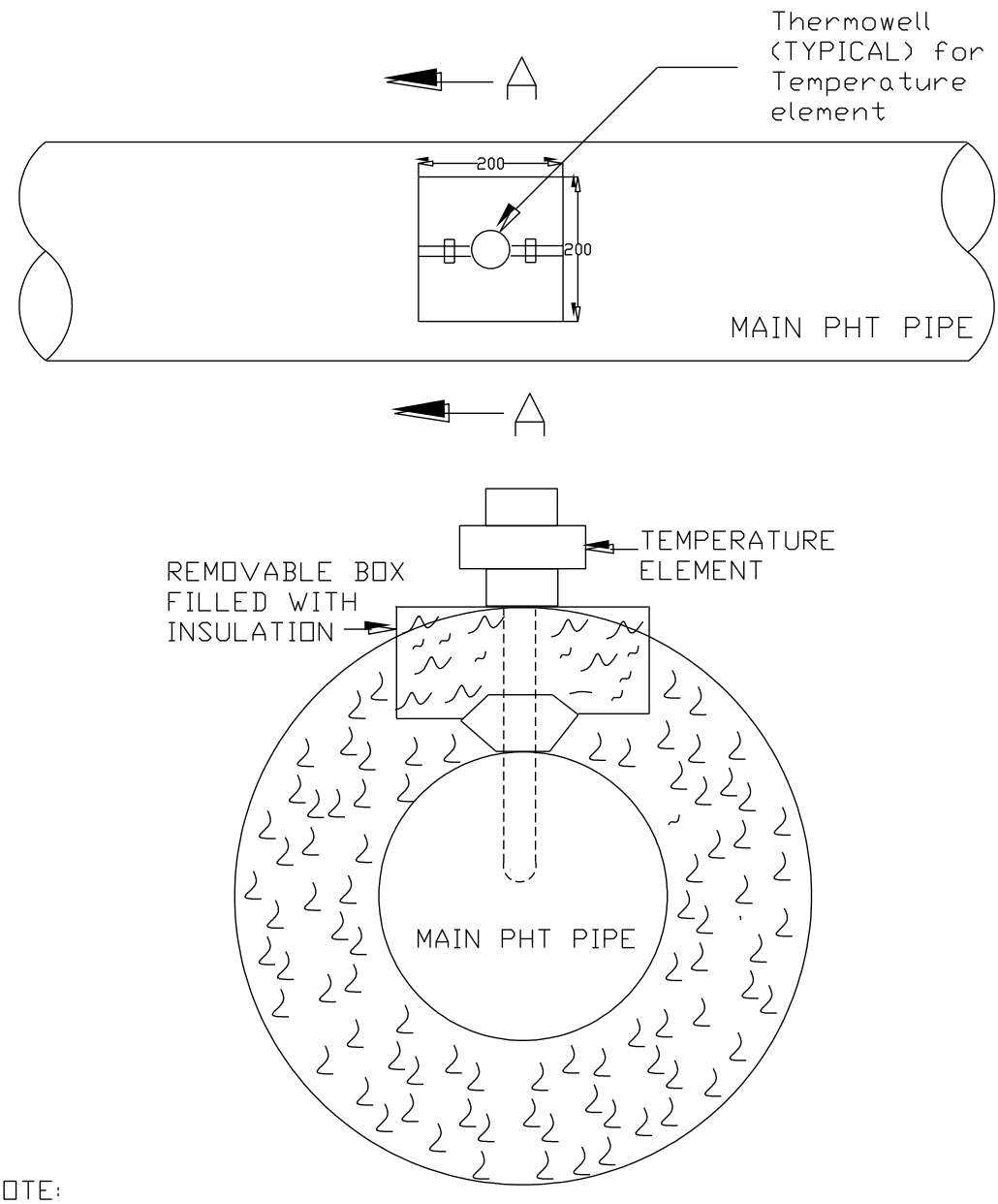
SKETCH–VII

TYPICAL ARRANGEMENT FOR HX
(SHUTDOWN HX & SECONDARY SIDE HXS AND OTHER
HXS REQUIRING INSERVICE INSPECTION)



SKETCH–VIII

REMOVABLE INSULATION (RECTANGULAR BOX) IN TWO HALVES FOR EASE OF MAINTENANCE OF TEMPERATURE ELEMENT (TYPICAL)

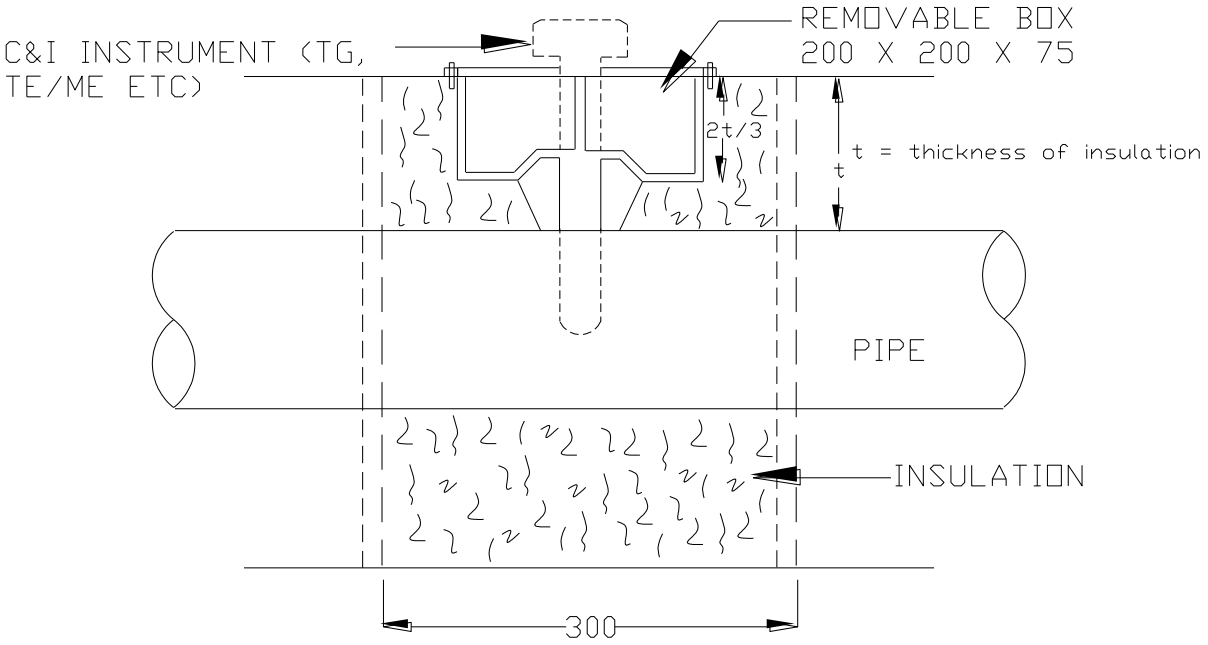


NOTE:
The details are as implemented at TAPP-3&4 Site

VIEW A - A

SKETCH - IX

REMOVABLE INSULATION BOX DETAILS FOR C&I TAPPINGS (TG, TE, ME ETC)



NOTE: SUITABLE PRECAUTIONS WILL BE TAKEN TO AVOID HEAT STREAMING

ALL DIMENSIONS ARE IN MM

SKETCH - X

NUCLEAR POWER CORPORATION OF INDIA LTD.
(A Government of India Enterprise)

SPECIFICATION NO. : **PC-P-285**

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DATE OF ISSUE (MONTH / YEAR) :	July, 2008	June, 2011				
TOTAL NO. OF PAGES (Including Cover Sheet) :	**92**	93				

TECHNICAL SPECIFICATION

FOR

FIELD WELDING OF PIPING

FOR NUCLEAR POWER PLANTS (PHWRs)

PREPARED BY : Sd/-

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APPROVED BY : Sd/-

K.N.Gupta

Name Signature Date

(For Revisions see Revision Control Sheet)

File Name: PC-P-285(R1)
Floppy No.:

REVISION CONTROL SHEET

DOCUMENT TYPE: TECHNICAL SPECIFICATION

NO. : PC-P-285

TITLE: TECHNICAL SPECIFICATION FOR

FIELD WELDING OF PIPING FOR NUCLEAR *POWER PLANTS (PHWRs)*

REV. NO. & DATE	DESCRIPTION OF REVISION	PREPARED BY	CHECKED BY	REVIEWED BY	APPROVED BY
0 July, 2008	Original Total Pages : 2 + 90	Sd/- J.C. Tripathi	Sd/- P.C. Katiyar	Sd/- D.P. Sharma	Sd/- K.N. Gupta
1 June 2011	1) Clause 15.1 & 18.3 has been revised for gas purity level . 2) Appendix-H – USI 34980, 36110, 34330 35216, 35226 & 62136 have been added 3) Appendix-I – Low hydrogen electrodes modified to 7018-1 4) Total 2+91 Pages	06.06.2011 J.C. Tripathi	06.06.2011 G.M. Arora	6/6/11 S. Vijay Kumar	7/6/11 A.K.Chakrabarti

1.0 SCOPE

1.1 This specification defines the requirements concerning to welding of piping for the forthcoming NPP's (PHWR). It is applicable to field welding/shop welding at site /stations. It is to be read in conjunction with Nuclear Power Corporation of India Ltd (NPCIL) Specification PP-P-548, Piping, fabrication and erection at the NPP's.

1.2 The requirements stipulated are based on piping systems and materials specified for construction at the time of writing this specification. Any subsequent design changes or authorized materials substitutions shall require review of the appropriate sections of this specification and amendments, as required.

1.3 Wherever the term NPCIL Quality Surveyor appears in this Specification it shall mean the authorized representative of NPCIL Quality Assurance unless otherwise stated.

1.4 The requirements of this specification are based on latest ASME Boiler & Pressure Vessel (B&PV) Codes/ASTM Standards/ANSI Standards /AWS Standards /BIS Publications. Reference to these Code and Standards is required only to the extent and in the instances where called for in the specifications issued by NPCIL. In the event that certain technical requirements are not fully described in this specification, the contracting party shall obtain the clarification from Engineer-in-charge, prior to start the job.

1.5 In the event that certain requirements of ASME Boiler & Pressure Vessel (B&PV) Codes/ASTM Standards /ANSI Standards /AWS Standards /BIS publications conflict with those of this NPCIL Specification, the governing requirements shall be as per this NPCIL Specification.

1.6 Unless otherwise specified, latest version of applicable ASME Boiler & Pressure Vessel (B&PV) Codes/ASTM Standards /ANSI Standards /AWS Standards /BIS Publication shall be followed in practice and shall be confirmed by the bidder in his bid / offer.

2.0 CONTENT

The specification requirements are presented under the following headings:

	Section
Scope	: 1.0

Contents	:	2.0
Welding Processes	:	3.0
Welding Procedures	:	4.0
Qualification and Performance Record of Welders	:	5.0
General Welding Requirements	:	6.0
Joint Design	:	7.0
Joint Fit Up	:	8.0
Weld Profile	:	9.0
Welding of Structural Attachments, Hangers and Supports	:	10.0
Tack Welds	:	11.0
Repairs	:	12.0
Seal Welds	:	13.0
Filler Materials	:	14.0
Shielding and Backing Gas	:	15.0
Heat Treatment of Welds	:	16.0
Welding of G.I. Pipes	:	17.0
Welding of SS Tubes with Automatic Tube Welding Machine	:	18.0
Brazing	:	19.0
Examination Methods and Requirements	:	20.0
Acceptance Standards	:	21.0
Welding Quality Control Records	:	22.0
Pre-Service Examination	:	23.0
Appendices		
Radiographic Examination of Welded Joints	:	APPENDIX-A
Magnetic Particle Examination	:	APPENDIX-B
Liquid Penetrant Examination	:	APPENDIX-C
Joint Design Drawings	:	APPENDIX-D
General Review of Material Specifications of NPP Piping	:	APPENDIX-E
Selection of Filler Materials	:	APPENDIX-F

Pre and Post Weld Heat Treatment of Welds	:	APPENDIX-G
Type of Weld and Classification of Examination Levels	:	APPENDIX-H
Guide to Welding Procedures in NPP's	:	APPENDIX-I
Ultrasonic Inspection	:	APPENDIX-J

3.0 WELDING PROCESSES

3.1 All piping shall be welded using either Shielded Metal Arc Welding (SMAW) Process or Gas Tungsten Arc Welding (GTAW) Process or a combination of the both. MIG Process may also be used in shop for mass production.

3.2 Oxy-acetylene brazing shall be used for brazing copper and copper alloys & Oxy-acetylene soldering process shall be used for soldering bronze to C. S. and Cast Bronze to copper alloys wherever required.

3.3 For welding of all grades of steel and nickel alloys by the GTAW process, 2% Thoriated Tungsten electrode conforming to latest edition of SFA-5.12 EWTh-2 classification shall be used.

3.4 Any other welding process, if proposed by the Contractor, shall require specific approval of the authorized representative of NPCIL.

4.0 WELDING PROCEDURES

4.1 The qualification of welding procedures shall be in accordance with latest edition of Section IX ASME Boiler and Pressure Vessel Code.

4.2 The Welding procedure specification form shall comply with the suggested format indicated in QW-482 of ASME Section IX Boiler and Pressure Vessel Code.

4.2.1	General Information	:	Contractors' (Fabricators') Name, Welding procedure specification No., Rev. (with dates), Supporting welding procedure qualification, Record No., Welding Process (es), Type (s) etc.
4.2.2	Joint details	:	Groove design, Backing provision, Backing material etc.
4.2.3	Base Metals	:	P. Nos. & Group Nos., thickness range, pipe diameter range etc.
4.2.4	Filler Metal	:	F. No., A No. SFA No., AWS No., size of electrode, size of filler, electrode flux (class), flux trade name, Consumable insert etc.,

4.2.5	Position	:	Position of groove, welding progression etc.
4.2.6	Preheat	:	Preheat temperature, inter-pass temp., preheat maintenance etc.
4.2.7	Post Weld Heat Treatment	:	Temperature, Time range etc.
4.2.8	Gas	:	Gas (es), % composition of mixture, flow rate, of the backing, trailing and shielding gas.
4.2.9	Electrical Characteristic	:	Current AC or DC, Polarity, Current Range, Voltage range etc.
4.2.10	Technique	:	String or Weave Bead, Orifice or Gas cup size, initial and inter-pass cleaning (mechanical), Oscillation, Contact tube to work distance, Multiple or Single pass, multiple or single electrodes, travel speed etc.

4.3 The specific facts involved in qualifying a Welding Procedure Specification (WPS), detailed in para 4.2, shall be recorded in a Procedure Qualification Record (PQR) Form QW 483 of Section IX ASME Boiler and Pressure Vessel Code shall be used for this purpose. This form shall document the essential variables of the WPS, the deposited weld metal thickness involved with each welding process and test result. These documents shall be certified by the authorized representative of the Contractor (Fabricator) and shall be made available for review and acceptance by the NPCIL Quality Surveyor. Change in any essential variable beyond specified limits shall require welding procedure re-qualification & to be recorded in another PQR.

4.4 Procedure qualification tests shall be performed at Site and the accepting authority shall be the NPCIL Quality Surveyor or his authorized representative. Any procedure already qualified in accordance with 4.2 may also be adopted. However, performance of welder qualification shall be required as per QW-300 of ASME Section IX Boiler and Pressure Vessel (B&PV) Code.

4.5 No welding work shall start until the procedure qualification tests for the particular type of welding have been accepted by the NPCIL Quality Surveyor.

4.6 The Contractor shall furnish ten copies each of approved & qualified procedures for record with Engineer-in-charge.

4.7 All test specimens shall be properly tagged and preserved for the duration of the construction by the contractor. The disposition of test specimens shall be as

directed by theEngineer-in-Charge.

4.8 The expenditure for performing the procedure and performance qualification tests as described in 4.0 shall be borne by the Contractor.

4.9 A guide to the welding procedures for NPP piping's is given in Appendix-I. Any party undertaking Project piping work shall verify this with the actual requirements of the ASME Section III NB/NC/ND & Section IX Boiler and pressure vessel code and shall qualify any additional procedures as required.

4.10 All welding procedure qualifications tests shall be performed in accordance with the requirements of ASME Section IX. Welding qualification requirements of clause no 4300 of NB/NC/ND of Section III of ASME Boiler and Pressure Vessel (B&PV) Code shall also be met.

Impact testing of weld metal for Welding Procedure Qualification test for production qualification exceeding 16 mm in thickness shall be performed in accordance with clause no 4335 of NB/NC/ND of Section III ASME Boiler and Pressure Vessel (B&PV) Code or whenever called for as per the drawing documents .

This is applicable for all piping system in Reactor Building. Impact tests are not required for austenitic and non-ferrous weld metal for all thickness of material for pipe, tube and fittings with a NPS 6 inch (i.e. 150 NB) diameter and smaller.

4.10.1 Acceptance standard for impact testing.

Nominal Wall thickness in mm	Lateral Expansion in mm (min).					Absorbed Energy (min.)		
	NB	NC		ND		NB	NC	ND
		Average of 3	Lowest of 3	Average of 3	Lowest of 3			
Over 16 to 20 including	0.5	0.5	0.4	0.35	0.25	50 ft-lb (68 J)	As per Table NC-2332.1-2	As per Table ND-2331(a)-2
Over 20 to 25 including	0.65	0.5	0.4	0.40	0.25			
Over 25 to 40 including	0.65	0.65	0.5	0.50	0.40			
Over 40 to 60 including	1.00	0.90	0.75	0.65	0.50			

4.10.2 Three charpy V-notch test (Cv) Specimens shall be tested at a temperature lower than or equal to the lowest service temp. All three specimen shall meet the requirements of para 4.10.1.Lowest service temperature can be taken as +18°C.

4.10.3 The charpy V-notch test (Cv) when required shall be performed in accordance with SA 370, Fig. 11, type A. The test shall consist of a set of three full size 10x10 mm specimens. The test temperature, lateral expansion, the absorbed energy shall be recorded & verified by the authorized representative of NPCIL.

4.10.4 Location & orientation of impact test specimens

Impact test specimen shall be located so that the longitudinal axis of the specimen is at least 0.25 t from weld surface and where thickness (t) of the test assembly permits, not less than 10 mm from weld surface of the test assembly. The specimen shall be transverse to the longitudinal axis of the weld with the area of the notch located in the weld. The length of the notch of the charpy V notch specimen shall be normal to the surface of the weld.

5.0 QUALIFICATION AND PERFORMANCE RECORD OF WELDERS

5.1 All Welders working on NPP piping shall have to pass the performance qualification test in accordance to Section IX of the ASME Boiler and Pressure Vessel Code. In addition, for the welder working in critical areas of limited accessibility (e.g. feeder etc) the performance qualification shall include mock-up test simulating field conditions which restrict the welder /s accessibility to the production weld joint within 35 cm (or actual field restraint which ever is governing) in any direction of the joint. Separate qualification is required at no extra cost to NPCIL, whenever significant different restricted accessibility conditions occur.

5.2 The qualification tests shall be performed at Nuclear Power Project (NPP)/ Shop and the qualifying authority shall be the Quality Surveyor appointed by the NPCIL.

5.3 The Quality Surveyor shall have the right to call for further qualifications of any welder who in the Quality Surveyor's opinion is not producing finished welds in accordance with clause 4.1 above, or who has discontinued welding by the particular process for more than three months, without any extra cost to NPCIL.

5.4 For each welder, a record card shall be maintained showing the procedures for which he is qualified. These cards shall contain the date on which the procedure used, the type of defects produced if any and their frequency. The record shall be reviewed once a week by the NPCIL Quality Surveyor and those welders whose work required a disproportionate amount of repair shall be disqualified from welding on the permanent piping joints. Requalification of a welder who has been disqualified more than three times to produce sound welds shall be entirely at the discretion of the NPCIL Quality Surveyor.

5.5 When repairs are to be made, the welder/s whose work is defective, the nature of the defects shall be explained to him. It is required that welder/s shall repair his own defective welds.

5.6 Each welder shall be assigned a letter, number or symbol. Each weld shall be

clearly identified as to its welder either by maintaining a Weld Data Sheet (WDS) in detail for every weld joint or by marking by vibro-etching on the pipe adjacent to the weld. If vibro-etching is used it should low stressed & not infringe upon minimum wall thickness requirement and is subjected to the approval of the NPCIL Quality Surveyor. The WDS shall be signed by the contractor's as well as NPCIL Quality Surveyor or his authorized representative.

However on pipe with wall thickness exceeding 6mm, low stress, round nose continuous or round nose interrupted dot die stamps may be used and stainless steel may be marked by an electrolytic etching method.

6.0 GENERAL WELDING REQUIREMENTS

6.1 No welding shall be done on surfaces which are wet or exposed to rain or excessive draft. Surfaces to be welded shall be free from paint, rust, oil, grease, dust or any other contamination. Cloths used for cleaning shall be lint free with hemmed edges. Weld edge shall be cleaned only by using NPCIL approved solvents.

6.2 Welds shall be cleaned each pass to remove all traces of slag and flux before next beads or layers to be deposited. Completed weldments shall be cleaned to the same extent. The craters at the starting and stopping points of each individual bead shall be carefully examined and any defects shall be removed by grinding. Grinding wheels, wire brushes, chisels etc. for use on stainless steel shall not be used on any other materials. The grinding wheels should be iron free and the wire brushes should be of austenitic stainless steel to avoid iron contamination of the stainless steel surface.

6.3 Peening shall not be permitted.

6.4 Purging dams may be used with proper administrative control .Purging dams shall be placed in such a position that they can be removed intact. The removal of dams shall be done to the satisfaction of NPCIL Quality Surveyor. The burning out of dams is not permitted. Dams shall be fully identified (by numbering etc.) and accounted for to eliminate the possibility of leaving them in the system. Soluble dam as mentioned in para 15.5 may be used with the approval of NPCIL Quality Surveyor.

6.5 Inspection and Quality Surveillance shall be as per approved QAP containing all dimensions specified for welding including weld size, reinforcement, and edge preparation, fit up etc. checked with the approved gauges by NPCIL Quality Surveyor. All aspects of the materials, fabrication procedures and examination procedures used, that could affect the quality of the finished weld, shall be

subjected to the approval of the NPCIL Quality Surveyor. The equipment to be used shall be suitable for the quality of the work specified and the technique employed shall be based on methods which are known to produce good results and which have been verified at site by actual demonstrations.

6.6 The welding technique and arc manipulation shall be controlled to ensure the following:

a) Full Penetration for groove welds.
b) Full fusion into the preceding bead or layer.
c) Full fusion into the base metal without undercutting along the sides of the weld.
d) Uniformity of surface in both single run passes and beaded layers.
e) Floating all slag, oxide and gases to the surface behind the advancing arc.
f) Delay in electrode travel until base metal fusion at the starting point is assured and until the crater is well filled at the completion of the weld.

6.7 Indiscriminate striking of the electrode on the base metal in establishing the arc is not permitted. The arc should be struck either in the joint where the metal surface will be fused into the weld or on a starting tab. Starting tabs shall be of the same material or a material compatible with the base metal being welded. When inadvertent arc strikes occur, the areas affected shall be ground flush and then examined by the magnetic particle or liquid penetrant method. High frequency arc starting devices shall be used for GTAW on heavy water system.

6.8 Care must similarly be taken when stopping the arc to avoid an unfilled crater and crater cracks. The following techniques are to be used for stopping the arc:

1) The arc should be drawn off to the side of the joint and stopped on the bevelled surface of the joint while extending the arc length rapidly.

2) In GTAW, the machine should ideally be equipped with a foot or hand control to permit a gradual decrease of current. It is then easier to fill the crater completely and prevent crater cracks. Alternatively the arc shall be extinguished as mentioned in (1) above.

6.9 When welding stainless steel, a stringer bead technique shall be used with a slight oscillation if necessary to avoid entrapped slag and to minimise the number of beads needed to fill a joint. Because of the higher coefficient of expansion and lower thermal conductivity of stainless steel, it is necessary to take precautions to control distortion. Skip welding, back step welding or effective tack welding before hand are the usual methods used. Control of interpass temperature is essential. The method to be adopted shall be stated in the welding procedure.

6.10 When welding carbon steel with covered electrodes, the width of the deposited

pass shall not exceed three times the nominal core wire diameter. For vertical position stringer bead is preferred.

6.11 Vertical welds shall be made in an upward direction. On pipes over 300 mm NB, welding shall be done whenever possible, by two welders working simultaneously on both sides of the pipe.

6.12 In GTAW the electrode tip must be correctly shaped; pointed for DC welding and spherical for AC welding. The electrode extension beyond the gas cup should be kept as short as is consistent with joint being welded. The welding torch should be inclined slightly in the forehand welding position and the filler metal to be added carefully to avoid contact and the consequent contamination of the tungsten electrode. The contamination should be checked periodically. If contamination does occur, the tungsten electrode shall be cleaned and redressed periodically. Similarly, if the tungsten electrode comes into contact with the weld pool the operator shall break the arc and grind out the tungsten deposit.

7.0 JOINT DESIGN

7.1 The Weld edge preparation (WEP) shall be as per the relevant approved drawings. Appendix 'D' lists these drawings and relates particular systems, Weld edge Preparation (WEP) and fit-ups.

7.2 Where counter-boring or any other machining is done, the remaining wall thickness of pipes or fittings shall not be less than that shown on the joint design drawings. The length of counter bore shall be 2X "t"min for pipe and "t"min for component & fittings to facilitate Pre Service Inspection (PSI), for details on PSI also refer clause no. 23 & Appendix "J" of this specification.

7.3 All circular butt welded joints shall have their WEP formed by machining, preferably on a Lathe/Beveling machine. Any machining equipment to be used for this purpose must achieve the accuracy specified for the particular WEP. Joints of other geometry may be prepared by drilling and hand grinding.

7.4 Where the circumstances do not permit machining or grinding, flame cutting may be used on carbon steel material for WEP, provided the cut edge is ground back at least 1.5 mm below the deepest indentation to remove Heat Affected Zone (HAZ).

8.0 JOINT FIT-UP

8.1 All weld joint fit-ups shall comply with the tolerances specified on the design drawings & Appendix 'D'.

8.2 Prior to starting fabrication, the relevant purchase specifications for materials shall be thoroughly studied to asses the tolerance on the supplied materials and compatibility & any other relevant aspects to meet the specified fit-up tolerances.

8.3 Before fitting up the weld joint, the profile and dimensions of the weld edge preparation shall be checked. If the specified tolerances exceeded than this shall be corrected by grinding, machining or any other method acceptable to NPCIL.

8.4 All fit-ups shall be examined by the contractor using suitable gauges prior to welding the root pass. All the fit ups for class-I system shall be examined by NPCIL Quality Surveyor and randomly for class-II & III system.

9.0 WELD PROFILE

9.1 Unless otherwise specified, all butt end welds shall be full penetration welds. The external surface of the weld shall be free from undercuts, overlaps and abrupt ridges or valleys. The weld metal reinforcement on the outside surface of the pipe shall not exceed the following limits:-

Component thickness (mm)	Maximum Reinforcement (mm)
Upto 12	1.6
Over 12 to 25	2.4
Over 25 to 50	3.2
Over 50	4.0

The reinforcement shall be crowned at the centre and shall taper smoothly to the surfaces being joined.

For the weld joints which are to be Ultrasonic (UT) examined for Pre-Service Inspection (PSI) as per point 23 of this specification, the weld reinforcement shall be dressed suitably to facilitate UT examination of joints in accordance with ASME Section-XI and procedure approved by NPCIL Quality Surveyor.

9.2 The surface smoothness of the finished weld shall be suitable for proper interpretation of the non-destructive examination including UT of the weld. To achieve that grinding if necessary shall be done and the weld shall be blended into the parent metal without thinning the basic wall thickness of the parent metal or weld metal in any way. Uneven or excessive grinding may be cause for rejection or re-work.

9.3 When components of different outside diameters are to be welded together there shall be a gradual transition between the two surfaces. The length of the transition shall be such that the length to offset ratio shall not be less than 3 to 1.

9.4 The root pass of butt welds without inserts shall have less than 1.6 mm internal

reinforcement. Defects such as crack, icicles, burn-through, lack of fusion, lack of penetration etc. shall be cause for rejection and repair of the weld.

9.5 The root pass of butt welds made with insert shall be essentially smoothened inside of the pipe and shall show no crevices or abrupt changes in section.

The tolerance of 1.6 mm internal reinforcement in welding without inserts and 0.8 mm with consumable inserts is acceptable.

9.6 Fillet welds may vary from convex to concave & shall be free from *defects like* undercutting and over-lap at the toe of the weld. A fillet weld in any single continuous weld may be less than specified fillet weld dimension by not more than 1.5 mm provided that the total undersize portion of the weld does not exceed 10% of the length of the weld .Individual undersize weld portion shall not exceed 50 mm in length. Full fusion shall be obtained at the root of the fillet. Typical profiles and requirements are shown in Appendix D.

9.7 The profiles of welds on branch connections depend on the type of the attachments and shall be as per the approved drawings.

There are branch connection fittings in the market which have extra thickness at the nozzle weld to compensate for weakening. Such fittings are called integrally reinforced branch connection fittings, e.g. weldolets, sockolets, elbowlets, latrolets, threadolets etc.

In some cases the extent of welding to be done on integrally reinforced branch connection fittings is indicated by a machining line on the fittings supplied by manufacturer as shown in drawings of Appendix-D. Where the extent of welding in such a form is not indicated, the same shall be decided in consultation with the Engineer.

All the nozzle welds shall be of full penetration type. In normal cases the outside of nozzle welds are having a fillet weld to avoid sudden change of section. It may be noted that the fillet weld is provided not for increasing the strength of nozzle weld but for having a gradual change of cross-section.

A sketch for gradual change of weld profile of branch connection pipes is shown in drawings of Appendix-D.

10.0 WELDING OF STRUCTURAL ATTACHMENTS, HANGERS AND SUPPORTS

10.1 In general structural attachments, hangers and supports shall be welded with SMAW process using covered electrodes.

10.2 At places where the structural attachments, hangers and supports are to be welded to either piping or adjoining components fabricated with GTAW process having a wall thickness of 6 mm or less, the joining weld shall be made by GTAW process with the addition of filler wire. This shall be considered as part of the support erection.

10.3 Attachments such as lugs, brackets, rings and other non-pressure parts that are welded to the pipe to form an integral and permanent attachment shall be in accordance with the details shown in approved drawings.

10.4 Temporary attachments shall be made by the qualified welder using qualified procedure .Wherever such temporary attachments are required to be retained, the material of hanger and supports shall be compatible with the base material to which it is attached.

10.5 All attachment welds and welding of hangers and supports shall be done by qualified welders and in accordance with qualified procedures. Welds shall be preheated and post weld heat-treated as called for in the appropriate welding procedure.

10.6 When required by Appendix-H, the attachment welds shall be completely examined by the magnetic particle or the liquid penetrant method. Any defects so revealed may be cause for repair or rejection.

10.7 Temporary attachments shall be removed in a manner that will not damage the present material. The removal can be done by grinding, chipping, sawing or in the case of heavy weldments by arc gouging or flame cutting. The attachment may be reduced to a very small cross-section and then the attachment "Knocked-off". "Knocking off" of full size attachment welds or tacks is not permissible.

When flame gouging is used atleast 3.2mm of metal shall be left on the surface which will then be removed by grinding. Such gouging shall be done tangentially to the pipe surface and the pipe surface shall be suitably protected.

10.8 The areas from which temporary attachments have been removed shall be dressed, smoothened and be examined by the magnetic particle or liquid penetrant method. Defects shall be removed and material re-inspected to ensure their removal of the defects. If weld repairs are necessary, they shall be made using qualified procedures and welders and shall again be examined by the magnetic particle or liquid penetrant method or Radiography depending on the depth of repair as per applicable code/ standard.

10.9 Whenever welding with main structure of the building is required, the prior approval of the Engineer-in-Charge shall be obtained to perform the welding.

11.0 TACK WELDS

11.1 All tack welds shall be made using a qualified procedure and qualified welders. Any preheat requirements specified in the welding procedure shall also apply to tack welds.

11.2 The number and size of the tack welds shall be kept as small as is consistant with adequate strength and joint alignment.

11.3 All tack welds shall be examined visually for defects and if found defective shall be completely removed.

11.4 As the welding proceeds, tack welds shall be either removed completely or shall be properly prepared by grinding or filing their stopping and starting ends so that they may be satisfactorily incorporated into the final weld.

12.0 REPAIRS

12.1 Any weld repair shall be carried out in consultation with the NPCIL Quality Surveyor.

12.2 Unacceptable defects (See Paras 21.2 & 21.3) shall be removed by grinding, machining or chipping. Arc gouging or flame cutting are also permitted provided gouged surfaces are ground back at least 1.6 mm below the deepest indentation.

12.3 If preheat is specified in the appropriate welding procedure then the same preheat must be maintained during flame cutting or arc gouging.

12.4 Liquid penetrant or Magnetic particle examinations shall be used to check that the defect has been completely removed prior to weld repair. In the event of any doubt regarding complete removal of a defect, radiography may be required.

12.5 Weld repairs shall be made using qualified procedures and welders. The preparation for the weld repair shall have the prior approval of the NPCIL Quality Surveyor. PWHT requirements for repair weld, if required, shall be same as those of original welds.

12.6 In the event of unsuccessful repair attempts twice or if the NPCIL Quality Surveyor feels that a satisfactory repair is not feasible, the joint shall be completely remade. Due consideration shall be given to check the damage of the parent material.

12.7 The rewelded area shall be re-examined by the methods specified for the original weld. Where radiography is required, a minimum amount of 50mm film overlap beyond the repair edges must be ensured. If construction of the assembly prevents

meaning full radiographic examination ultrasonic examination may be substituted provided the weld has been previously radiographed and met the acceptable standards.

12.8 Repairs of any base material utilised in fabrication of piping shall not be undertaken unless specifically permitted by the Engineer-in-Charge.

13.0 SEAL WELDS

13.1 Seal welding shall be done by qualified welders and in accordance with approved procedures.

13.2 Threaded joints that are to be seal welded shall be made without the use of a thread lubricating compound.

13.3 The surfaces to be welded either side "2X t min" shall be cleaned free from paint, grease, oil, rust, seal compound, etc.

13.4 The threads left outside after making the joint shall be adequately prepared by grinding and circumferentially covered by the seal weld. The surface of the seal weld shall merge smoothly into the parent metal surface and shall be suitable for the proper interpretation of non-destructive examination of the weld. Unless otherwise specified on drawings, seal welding including slip on flanges shall be of size 2 mm(min), to the extent possible, seal welding shall be done in two passes.

13.5 Seal welds shall not be considered as contributing to the strength of the joints. Backing off, to correct misalignment, of screwed connections is not permitted.

14.0 FILLER METALS

14.1 The selection of filler metals for welding of piping shall be on the basis of Appendix F.

14.2 Only basic coated electrodes are acceptable for carbon steel and stainless steel welding. Only NPCIL approved brands of electrodes & filler wire shall be used. All welding materials shall conform to AWS classification and shall comply with the requirements of applicable codes. For each batch of each approved brand, certificates showing compliance with the specification shall be submitted to the NPCIL Quality Surveyor before being released for use on Project Piping. Delta ferrite content on austenitic stainless steel welding material including consumable inserts shall be min. 5% (5 FN) and max. 9.2% (10 FN) and would be determined as per NB 2433.1 of ASME Section III.

14.3 All electrodes shall be stored in their original sealed container and under dry conditions (50% maximum Relative Humidity). The electrodes shall remain

identified until consumed.

14.4 All electrodes shall be dried before use in accordance with manufacturer's instructions. Drying ovens shall be provided in work areas for this purpose. Each lot of electrodes withdrawn from the oven shall be used within two hours. During periods of high humidity, use of electrode with in a shorter period less than 2 hrs may be necessary. Electrodes not used during this period shall be returned to the ovens. Electrodes shall not be left at work locations whether in metal containers or otherwise. In the event that electrodes are left out for period longer than two hours they shall be examined and rebaking will have to be done.

14.5 Electrodes which have been exposed to rain or otherwise exposed to water shall be discarded & documented. No rebaking of such contaminated electrode will be permitted.

14.6 For systems where a high quality butt welded joint is required, consumable inserts are specified (see Appendix-F). More consistent control of the Chemistry and microstructure of the root pass can be obtained by using inserts than by any other method. Gas backing (purging) is necessary and the insert shall be fused using the GTAW process. Gas backing is not necessary at the tacking stage.

14.7 Thc standard shapes, styles, sizes and tolerances for inserts on various dimensions conforming to SFA 5.30 shall be used in circumferential butt welded joints are as follows. Usage of inserts for CS piping's of secondary cycle (inside & outside RB) and other systems as per NC& ND is optional .The filler wire for subsequent passes shall be as per QW 404.22.

a) Class 1, inverted T- Shaped Cross-Section
Style A, Coiled consumable insert
Style B, preformed rings, opens lap joint
Style C, Preformed, open butt joint
Insert size available 3.2 mm and 4 mm.

b) Class 3, rectangular - shaped cross-section
Style D, Solid rings 4.8mm rim width
Style E, Solid rings 3.2mm rim width

c) Class 4, Y-shaped cross-section
Style A, Coiled consumable insert
Style B, Preformed rings, opens lap joint
Style C, Preformed rings, opens butt joint
Insert size available 3.2mm and 4mm

d) Class 5, rectangular - shaped cross-section
(Contoured edges)

Style A, Coiled consumable insert
Style B, Preformed rings, opens lap joint
Style C, Preformed rings, opens butt joint
Insert size available 1.2 mm, 3.2mm and 4mm

Class 1, style A insert S.S. material will be generally procured in coil form of 3.2mm and 4mm size. Smaller size (3.2 mm) is recommended for use on pipes up to 100 NB. This material shall be cut and formed to suit the edge preparation of the pipe. Suitable numbers of windows shall be cut during fit up for viewing the root pass to ensure proper fusion of insert subsequently the windows should be closed with proper filler wire.

Class 3, Style D or Style-E is recommended for use in feeder pipe.

The type of insert to be used for a weld joint shall be determined by the edge preparation on equipment nozzles or valve ends. The contractor to be permitted to use any of the applicable inserts with due approval of NPCIL Quality Surveyor on joints when pre-machined weld edge preparation is not available e.g. pipe to pipe joint.

14.8 A complete description of the characteristics of the consumable insert classification is covered by (i) SFA 5.30, specification for consumable inserts, (ii) AWS D10.4 - '79, Recommended practices for welding Austenitic Chromium - Nickel stainless steel piping and tubing, and (iii) AWS D10.11 - '79 Recommended practices for root welding and gas purging.

14.9 When welding in the horizontal fixed position with flat inserts, the insert should be positioned slightly inside the pipe at the bottom of the pipe and flush with the inside of the pipe at the top. Welders will require training and experience to achieve the smooth, uniform 0.8mm maximum internal reinforcement specified using consumable inserts. Concavity, suckback, burn through and excess penetration are the major defects to be avoided. The welding of the second pass also requires considerable technique to avoid defects in the completed root pass. Welders shall pass performance tests in accordance with Section IX of the ASME Boiler and Pressure Vessel Code with the added requirements of this and other relevant specifications.

14.10 The fusion of a preformed filler wire in the root pass in a similar way as that of the consumable insert of certain groove joints is permissible at the discretion of the Quality Surveyor.

14.11 For thin walled stainless steel piping (150 NB and above upto SCH 30) of SFSB cooling system and end shield cooling system, use of consumable inserts are

optional.

14.12 Any change in the type (class/style) of insert requires separate performance qualifications.

15.0 SHIELDING AND BACKING GAS

15.1 Argon gas used in GTAW process for shielding and purging shall be *99.99% (min.)* pure having moister 10.5 ppm & dew point -60°C (CGA class Type –I grade C as per SFA 5.32).

The rate of flow for shielding purposes shall be established in the procedure qualification.

15.2 Purging or backing gas is required in the GTAW process to protect the underside of the weld and the adjacent base metal surfaces from oxidation during welding. When purging, a high gas pressure is not desirable, the requirement is for a small gas flow to maintain the purge. Whether the GTAW process or a combination of GTAW and SMAW is specified for a particular joint the purge shall be maintained during welding of the root pass and for atleast one subsequent pass to minimise oxidation on the inside surface of the pipe. It is suggested to maintain the purges untill three layers or 4.8mm root thickness is obtained. Since the second and third passes in the joint may take the previously deposited consumable insert root pass above the oxidising temperature of the base and filler metal.

15.2.1 The above provision shall be applicable for entire PHT system, Welds joint inside Calandria Vault, Weld joints of Alloy Steel (P3&P5) and all joints with inserts (CS&SS)

15.3 Purging at a flow rate of approximately 0.28 M.cu/hr subjected to maximum of 1.4 M.cu/hr depending on diameter of pipe until 6 times the volume of the section of piping between the dams has been replaced is usually adequate. In no case should the initial purge be for less than 10 minutes.

15.4 After initial purging is completed, the flow of backing gas during welding be reduced to a point where only a slight positive pressure pervails. For systems which have a small volume (upto 14 liters) to be purged during welding, a gas flow rate of 0.14 M.cu/hr is usually adequate. Systems of larger volume may require higher flow rates and these should be established at the procedure qualification stage.

15.5 Soluble dam in limited area, where it is absolutely necessary may be used with the approval of Engineer. Total leachable chloride content in the paper shall not be more than 25ppm.

16.0 HEAT TREATMENT OF WELDS

16.1 Heat treatment shall be accomplished by a suitable heating method that will provide the desired heating and cooling rates, the required metal temperature and the uniformity of temperature distribution required by Appendix G of this specification.

16.2 As far as practicable, post weld heat treatment of pipe sections or sub-assemblies, particularly branch welds, should be done in a closed furnace. Prior to starting the work, a feasibility study shall be made and which shall be approved by the Engineer, on the basis of which drawings shall be marked for sub-assemblies to be shop fabricated and heat treated in a furnace. The balance of field completed joints shall be post-weld heat treated by a circumferential band which includes the weld area using either the resistance heating or low frequency induction heating methods. The induction heating method is preferred. Alternatively local heating as per NB/NC/ND-4624.3, as applicable, by resistance heating shall be carried out. The inside surface of pipes in D_2O Systems and also of the pipes in other systems where cleaning of inside bore is not possible shall be protected from oxidation by inert gas/dry nitrogen purging.

Argon/Nitrogen purging during PWHT of CS piping may not be considered necessary provided it is demonstrated that no oxidation takes place during PWHT without purging.

16.2.1 The furnace provided should ideally be capable of accommodating the entire sub-assembly. In cases where the pipe sections or sub-assemblies are too large to be accommodated in one heat, the parts may be heated in more than one heat and the overlap of the heated portions is at least 150 cm. When this procedure is used, the cooling rate of the portion outside the furnace shall be controlled by insulation to provide a gradually diminishing temperature outward from the heated portion. The cross section where the part projects from the furnace shall not intersect a nozzle or other structural discontinuity

16.2.2 The loading temperature of the furnace shall not exceed 425 deg. C at the time the component is placed in it. During the heating and cooling period, the temperature throughout the portions of component shall not vary more than 140 deg. C within any 450 cm interval of weld length.

16.2.3 During the whole heat treatment cycle, the atmosphere of the furnace shall be so controlled as to avoid excessive oxidation of the surface of the material. The furnace shall be designed such that direct impingment of the flame on the material is prevented. The sulpher content of fuel shall be restricted to1% by weight of

residue.

16.2.4 Requirements for rate of heating and cooling, and minimum holding time in post weld heat treatment shall be as per Appendix-G.

16.3 Where induction or resistance heating methods are used, the width of the heated band on each side of the greatest width of the finished weld , shall not be less than twice the wall thickness of thicker component. For welded branch connection the width of heated band shall be equal to six times the main pipe wall thickness. Uniform temperature around the entire circumference of the piping shall be ensured. The cooling rate of the pipe or component on each side of the heating device shall be controlled to provide a gradually diminishing temperature away from the heated band during the entire post-weld heat treatment. This can be achieved by suitable spacing of the coils and by provisions of adequate insulation. The minimum width of insulation shall be double of heated band beyond each edge of heated band. Open ends of pipe lines should be plugged to prevent uncontrolled convection heat losses.

16.4 The use of gas torches and gas rings shall be restricted to preheating operations not exceeding 125 deg. C and shall require approval of the NPCILQuality Surveyor. All gas heating must be done with a neutral flame only. Temperature uniformity must be ensured by moving the torch around the object or by using several torches. The temperature must be checked by temperature indicating crayons. Thermocouples are not suitable for this purpose because of quick response to direct contact with the flame and thus prone to false indications.

16.4.1 An automatic time/temperature recording of all post-weld heat treatments shall be provided. Time-temperature recording of all PWHT shall be made available for review by NPCIL Quality Surveyor. Weld joints to be identified on time temperature recording chart & shall be provided for permanent record. . For PWHT use of highly reliable and sturdy digital controller indicator – recorder of Yokogawa/Amtek make or similar or better instrument to be used.

16.4.2 When induction heating is used, only one thermocouple is required to control the operation. For heat treatment of members of unequal wall thicknesses the thermocouple shall be attached to the thicker member.

16.4.3 When resistance heating is used

1) For pipes smaller than 100mm NB, one thermocouple will be sufficient.
2) For pipes 100 to 200 mm NB at least two thermocouples shall be used.
3) For pipes 200 NB and over 3 or more thermocouples shall be used.
4) For branch connections the number of thermocouples to be employed and their location shall require Quality Surveyor's approval.

Where more than one thermocouple are used, they shall be spaced evenly around

the work.

16.4.4 For furnace heating operations, the number of thermocouples will depend on the design of the furnace and the size of object heated. Thermocouple positions and numbers shall be detailed in procedure and submitted for the approval of NPCIL Quality Surveyor. The heating furnace, thermocouples, compensating coils and recorders are required to be calibrated and accepted by NPCIL Quality Surveyor prior to heat treatment of the part. Validity of calibration is for a period of 6 months. In case of doubt regarding on its performance/ accuracy, re-calibration will be required even during the validity period.

16.4.5 The thermocouple wires shall not be directly tack welded to the base metal, but shall be encased in 6.4mm dia tube, approximately 20mm long, flattened to grip the thermocouple leads and the tube shall be tack welded to the base metal. The tube material shall be compatible with base metal. The two leads of the thermocouple shall be kept separated and clear of the work by individual encasement in asbestos tubing or porcelain beads for a distance of 150mm. The thermocouple extension leads shall be connected to the correct wires of the thermocouple and the proper terminals of the recording/controlling instrument. All connections shall be tight.

16.5 Proper support should be provided for the pipe line to avoid undue stress at the time of Heat Treatment.

16.6 All heat treatment operations shall be done in accordance with approved written procedure giving all particulars of the method to be used. The procedure shall be substantiated with design calculations showing energy requirements, selection of coils or wires, characteristics of power supply spacing and insulation requirements etc. The heating method proposed must have been tested under comparable conditions to verify uniformity of heating and required response of controls.

17.0 WELDING OF G. I. PIPES

17.1 The joint design, welding and inspection shall be as specified for non galvanised pipes mentioned in this specification.

17.2 Joints must be thoroughly cleaned immediately prior to welding to remove all oxides, paints, oil, grease, dust etc. Zinc coating shall be removed prior to welding as per procedure described in PP-P-550.

18.0 WELDING OF SS TUBES WITH AUTOMATIC TUBE WELDING MACHINE:

18.1 The SS tubes (SS-304 L) of OD 6 mm and above up to 25 mm (WT 1.2 mm and above up to 3.0 mm) shall be joined by single pass automatic gas tungsten arc

welding process without using filler material for all positions by means of rotating electrode in an automatic tube welding machine (Orbital welding machine).

18.2 The automatic tube welding machine shall be qualified for auto tube welding in accordance to machine manufacturer specification. WPS & PQR shall be maintained by site construction group.

18.3 The shielding and purging gas shall be Argon *99.9993%* pure (min) and conforming to IS-5760-2003. The gas hoses should be purged with a minimum of 3 volumes or for 2 to 3 minutes which ever is more to remove all air from the hoses during initial and after any extended period of interruption in the work progression. Maintaining internal purge gas pressure is of prime importance to achieve satisfactory weld profile and shall be determined in mock-up.

18.4 The tubes shall be handled carefully & the tube ends shall be square cut with hand operated tube cutter. Burrs shall be removed by suitable means, keeping the tube face down wards.

18.5 Ceriated Tungsten (2%) electrodes shall be used and sizes of the electrodes shall be as recommended by machine manufacturer. Each electrode shall be replaced after 30 welds or immediately after contamination/deformation.

18.6 Both tube ends shall be cleaned thoroughly using NPCIL approved solvents, just before assembling the tube joint in its weld head. The radial misalignment shall not be more than 10% of wall thickness of the tube.

18.7 After commissioning of welding machine 15 weld joints of each size of tubing and each position (2G & 5G) shall be made in one un-interrupted sequence and examined as per the detailed procedure by site construction group for qualification of welding machine. All the samples shall be checked visually for uniformity, free from porosity, undercut, incomplete/partial penetration, axial/angular misalignment etc. Out of 15 weld joints, 6 joints shall be longitudinally sectioned for internal examination, 3 joints for tensile test and balance 6 joints shall be checked for bend test as per clause 18.9. In addition to these tests, three test pieces for each position and size of tubing shall be made by the welder for qualification of welder. Two of these shall be cut open and subjected to internal examination and bend test as per clause 18.9.

18.7.1 Daily test prior to production welding (Daily machine qualification) - The welder shall produce two satisfactory weld samples in each position for specified size of tubing; before start of the work. Test welds will be longitudinally cut for internal examination. This will be the part of daily machine qualification.

18.7.2 Tests during production – No test shall be made during production, but the steady behaviour of the machine shall be checked with hard copy of welding parameters

to infer the uniformity of production welds. NPCIL Quality Surveyor, however, may visually check the joints for weld bead width, centering of the bead & arc wandering and depressions in the weld bead , based on the facts the quality surveyor shall decide the acceptable quality level. In case of deviation, requalification may be asked for.

18.7.3 Testing at the end of production welding (every day):- At the end of production welding, sample welds shall be made and subject to inspection if production welds are more than 30 nos in a day (samples are not required if production welds are less thanm30 no's per day) . Also, whenever Argon cylinder is changed two samples will be made and examined before starting actual production.

18.8 The welds shall be visually examined such that weld beads are of uniform width indicating that current is programmed properly & tapered during the overlapping phase, thus end crater due to arc extinguishing is avoided. The weld bead is evenly centered ensuring complete fusion of the both tube ends and absence of arc wanders. The weld width tolerance shall be : 3.18 mm $\pm$ 0.50 mm for 6 mm OD tubes, 3.43 mm $\pm$ 0.90 mm for 10 mm OD tubes & 3.80 mm $\pm$ 0.90 mm for 12 mm OD tube, 4.2 $\pm$ 1.0 mm for 20 mm OD tube and above. The weld beads shall be smooth, free from oxidation and shall have neither concave nor convex profile. The HAZ shall be with in 12 mm from the joint indicating that weld beads are not excessively hot before or during welding. The samples shall be cut longitudinally through the weld joint for internal examination. The joint should indicate complete penetration and there should not be any tool mark at the end.

18.9 Samples for bend test shall be at least 150 mm long in the weld in the center. The tube shall be cut open at the center longitudinally and bent 180° around a mandrel having diameter equal to 8 times the OD of tube, in such a way that the root of the weld is in tension. Root pass should not open up in this process.

19.0 BRAZING

19.1 The qualification of brazing procedures and brazers shall be in accordance with Section IX of the ASME Boiler and Pressure Vessel Code. When system design temperature exceeds 90 deg. C, tension test shall be done at design temperature.

19.2 All general rules concerning test specimens, procedures and records etc. described in this Specification in connection with welding shall also apply to brazing.

19.3 Brazing shall be performed by manual oxy-acetylene torches. Propane gas rings may be used for preheating but their proper use shall be demonstrated and subject to the NPCIL Quality Surveyor's approval.

19.4 All pipes and fittings shall be checked for proper cold clearance and adjusted to size by the Contractor where necessary.

19.5 The assembly shall be properly vented and supported to ensure maintenance of correct alignment during the heating and cooling cycle of the brazing operation. The method of supporting shall not be a source of externally applied stress.

19.6 Thorough cleaning to have oxide free surface is required to ensure uniform quality and sound brazed joints.

19.7 Brazing temperature must be achieved by rapid and uniform heating. Overheating must be avoided and this is best accomplished by using an active flux which has its melting point not too far below the brazing temperature range of the filler metal. The melting of the flux then serves as an indicator of the approach to the proper brazing temperature which is normally about 25 to 50 deg. C higher than the melting temperature of the filler employed.

19.8 Filler metal shall be fed by touching the joint which has been brought to the proper temperature and not by melting in the flame.

19.9 When the alloy has flowed completely, the flame should be removed and the joint allowed to cool undisturbed till 375 deg. C. Solidification of the alloy can be observed by a sudden change from very shiny to less shiny appearance of a fillet. At this time the joint has very low strength and if carelessly moved, a cracked joint may result.

19.10 After brazing, the flux must be removed since such fluxes are corrosive. Quenching from 375 deg. C after the brazing operation will break off most of the flux by thermal shock. Flux residues are usually soluble in hot water but it may take a considerable soaking time to remove a thick fused flux.

19.11 Brazed joints shall be assembled in a sequence that will permit the maximum number of joints to be visually examined wherever possible on both sides of the joint after brazing. Visual examination of brazed joints should not be attempted until all residual flux has been removed.

19.12 The completed brazed joints shall be visually examined on all accessible surfaces. Braze metal shall give evidence of having flowed uniformly throughout the joint by the appearance of an uninterrupted narrow visible line of brazing alloy on both sides of the joint. Optical aids not exceeding 10 X shall be employed for indirect visual examination to examine the joints that cannot be examined directly. (A fillet that is lumpy and has not evenly covered the two pieces, indicate that insufficient heat is employed. A fillet with a lacy appearance and with pin holes may indicate that too much heat is used and may be porous.).

20.0 EXAMINATION METHODS AND REQUIREMENTS

20.1 The type and extent of weld examination shall be as per Appendix-H, of this specification.

20.1.1 All non-destructive examination shall be done to a detailed written procedure that has been qualified by actual demonstration as capable of detecting and locating discontinuties described in this specification as unacceptable or as required to be reported. The procedure shall comply with the requirements described in the relevant appendices of this specification covering the particular examination method. An adequate number of copies of the procedure shall be readily available to all applicable non-destructive examination personnel for reference and use.

20.2 Radiographic examination of welds shall be performed after any required post-weld heat treatment. However, for pipe welds between P1 to P1 group of material, the radiographic examination may be performed prior to any required PWHT. If the weld is subject to stressing due to bending operation radiographic examination of the weld shall be done after bending and subsequent heat treatment if any.

Magnetic particle and liquid penetrant examination of welds for acceptance shall be performed only after heat treatment.

20.3 Following any non-destructive examination in which foreign material is applied to the surface, the surface shall be thoroughly cleaned in accordance with the applicable material or fabrication specifications. Cleaning shall be done immediately following the Quality Surveyor's inspection of the test in question.

20.4 All personnel performing any non-destructive examination shall be competent and knowledgeable of the applicable examination requirements and shall be qualified in the general technique and to the specific procedure. The NPCIL Quality Surveyor shall have the right to require re-qualification or change of any person who in his opinion is not performing the examinations satisfactorily. Guidelines for examination for qualification of personnel shall be as per SNT-TC-IA.

20.5 For non-destructive examination methods that consist of more than one operation or type, it is permissible to use personnel having qualification to perform one or more operation. One person may be used who is qualified to conduct the examination and another may be used who is qualified to interpret and evaluate the examination results. The qualification certificate shall describe this in detail.

20.6 **Visual Examination**

20.6.1 Visual examination is of the first order of importance. Its purpose is to ensure the conformity of the welded and brazed joints with all provisions and requirements

of the Specifications and welding procedures. Visual examination is mandatory for all welded and brazed joints and Appendix H gives part of the visual examination requirements of this specification.

20.6.2 This method of examination shall extend to cover atleast the following steps

a) Base metal identification w.r.t. corelating mill test certificates.

b) Base metal defects, if any, such as surface irregularities, cracks, or laminations.

c) Filler Metal identification and verification for any defects.

d) Edge preparation.

e) Joint fit-up.

f) Cleanliness.

g) Tacks.

h) Jigs and braces.

i) Purging provisions.

j) Root pass and subsequent passes appearance.

k) Cleaning between passes

l) Pre-heat, interpass, temperature and heat treatment control.

m) Appearance of completed welds, their conformity with drawings and specification and suitability for subsequent methods of examination.

n) Condition of base metal in the area adjoining the weldment.

o) Excessive or unexpected distortion due to welding.

20.6.3 Any deviation from the specifications and approved procedure shall be immediately reported to Engineer-in-Charge and his decision is to be obtained prior to proceed further.

20.7 RADIOGRAPHIC EXAMINATION

20.7.1 The radiographic examination shall be carried out in accordance with Appendix A/ (or a separate procedure) of this specification.

20.7.2 The results of radiographic examination be submitted for the approval of NPCIL Quality Surveyor.

20.7.3 The NPCIL Quality Surveyor shall have the right to reject any radiograph not conforming with proper techniques and/or processing.

20.7.4 The finished radiographs shall be preserved in good condition and shall be suitably stored until the work is completed. At the completion of the work, these radiographs shall become the property of the NPCIL and shall be handed over to NPCIL Quality Surveyor with complete identification with respect to line no., joint no., and its location, etc., Air-conditioned storage for the radiographs is required.

20.7.5 Where 5% radiography (Spot radiography) is called for, this shall be spread uniformly over all pipes diameters in a particular system as follows:

5% of linear length for pipe size 250 NB (including) and above.

5% joints may be selected from two groups of pipes welded by a particular welder. These groups of pipe sizes may be from a single system or from different systems using same WPS and having same level of inspection. Groups may be as under:

Group 1 : Up to and including 100 mm NB pipe size.
Group 2 : Above 100 NB and less than 250 NB pipe size.

Selection of the joints or location shall be at the discretion of NPCIL Quality Surveyor.

Joints welded by each welder shall be grouped in lots of 20 joints or 6 meters of weld as applicable. Each group shall be examined as soon as practicable after the completion of requisite welding so that effective monitoring of the performance of the welder is done on fortnightly basis.

20.7.5.1 As a verification process 5% repeat RT shall be carried out independently by Engineer or its authorized representative. In case of mismatch is observed between the two RT results (one taken by Contractor & other by Engineer), the contractor shall carry out repeat RT for all joints welded and radiographed in preceding Seven days without any extra cost to NPCIL.

In case of three such mismatches the following action shall be initiated:

1) NPCIL shall be at liberty to disqualify and /or withdraw the authorization of responsible key personnel of the main contractor and the concern task performer of the project.

2) The NDT agency shall be liable for disqualification and/or withdrawal of authorization by NPCIL in case such mismatch in repeat RT persist beyond such three occasion.

20.7.6 Evaluation and re-tests for spot radiography

20.7.6.1 When a joint or weld length of a group is acceptable, the remaining joints or weld length represented by the radiograph (s) shall be considered acceptable.

20.7.6.2 When a joint or weld length of a group is rejected, two additional joints or weld lengths from the group shall be radiographically examined. The location of these additional joints or weld lengths shall be at the discretion of the NPCILQuality Surveyor.

20.7.6.3 If the two additional joints or weld lengths examined are acceptable, the remaining joints or weld lengths in the group shall be considered acceptable. The defective welding disclosed (as mentioned in 20.7.6.2) shall be repaired and fully examined.

20.7.6.4 If either of the two additional joints or weld lengths examined is defective, all the remaining joints or weld length in the group shall be rejected. The contractor will however have the option to do 100% radiography and only those joints or weld lengths found to conform to the specification requirements shall be accepted. The rejected welds shall be repaired and fully re-examined.

20.7.7 For all drains and vent lines which are open to atmosphere, the butt weld joints at the down stream of drain / vent valve, need not to be radio graphed and the same may be checked by visual at root and visual & DP after final weld pass.

20.8 MAGNETIC PARTICLE EXAMINATION

20.8.1 Magnetic particle examination shall conform to the requirements with Appendix B of this specification. The examined material surface shall be demagnetized after this examination unless specifically exempted by the NPCILQuality Surveyor. Only NPCIL approved brands of Magnetic Particle Examination item shall be used. For 10% supplementary examination the joint selection shall be as per clause 20.7.5.

20.9 LIQUID PENETRATION EXAMINATION

20.9.1 Liquid penetrant examination shall conform to the requirements of Appendix C of this specification.

20.9.2 The penetrant, cleaner and developer shall be tested and certified as having acceptably low Halgoen(25ppm) and Sulphur(20ppm) contents of each batch. Only NPCIL approved brands of chemicals shall be used for penetrant testing. For 10% supplementary examination the joint selection shall be as per clause 20.7.5.

20.10 ULTRASONIC EXAMINATION

20.10.1 Ultrasonic examination of pressure bearing welds of some subsystems is required to obtain base line data for subsequent periodic inservice inspection of the system. The extent of examination and weld dressing requirements and acceptance standard shall be as per NPCIL specification no. PP-P-2009(Procedure for UT Examination of pressure retaining welds-steel piping and vessel butt joints) and are given in Appendix J of this specification.

21.0 ACCEPTANCE STANDARDS

21.1 VISUAL EXAMINATION

The acceptance standards for visual examination shall be as described in this specification.

21.2 RADIOGRAPHIC EXAMINATION: (NB 5320)

Indications shown on the radiographs of weld and characterized as imperfections are unacceptable under the following conditions:

a) Any indication characterized as a crack or zone of incomplete fusion or penetration;

b) Any other elongated indication which has a length greater than:-

6.0 mm for't' up to 19mm inclusive
1/3't' for't' from 19mm to 57mm inclusive
19 mm for't' over 57 mm

Where't' is the thickness of the thinner portion of the weld.

c) Internal root weld conditions are acceptable when the density change as indicated in the radiograph is not abrupt; elongated indications on the radiograph at either edge of such conditions shall be unacceptable, as provided in (b) above.

d) Any group of aligned indications having an aggregate length greater than 't' in a length of 12 't' unless the minimum distance between successive indications exceeds 6L, in which case aggregate length is unlimited, L being the length of the largest indication.

e) Rounded indications in excess of that shown as acceptable in Appendix VI of Section III, Division 1 of the ASME Boiler and Pressure Vessel Code (Latest Edition).

21.3 MAGNETIC PARTICLE AND LIQUID PENETRANT EXAMINATION (NB 5340 & NB 5350)

21.3.1 Only imperfections producing indications with major dimensions greater than 1.5mm shall be considered relevant imperfections.

21.3.2 The following relevant indications are unacceptable.

a) Any crack / or linear indications

b) Rounded indications with dimensions greater than 4.8mm
During PT examination of seal welds no indication shall be permitted.

c) Four or more rounded indications in a line separated by 1.5mm or less edge to edge.

d) Ten or more rounded indications in any 4000 mm^2 of surface with the major dimension of this area not to exceed 150mm with the area taken in the most unfavorable location relative to the indications being evaluated.

21.4 **BRAZED JOINTS**

a) Peel Test (QB 170 of ASME IX)

i) The total area of discontinuity (unbrazed areas, flux inclusions etc.) shall not exceed 25 percent of the total overlap area of any individual laying surface. The overlap shall mean full depth of the corresponding socket fitting supplied in Project piping.

ii) The sum of the lengths discontinuity of the measured on any one line in the direction of the lap shall not exceed 25 percent of the lap.

iii) No discontinuity shall extend continuously from one edge of the joint to the other edge, irrespective of the direction of the defect.

22.0 **WELDING QUALITY CONTROL RECORDS**

22.1 Welding quality control records shall comprise the following

a) Manufacturer's certificates for consumable supplies (filler metals, argon, liquid penetrant etc.) attesting compliance of the product with the specification issued by the NPCIL Quality Surveyor

b) Welding procedures.

c) Welders qualification certificates.

d) Procedures for non-destructive examination.

e) Qualification certificate of the personnel performing non-destructive examination

f) Procedure for heat treatment

g) Record charts for heat treatment

h) The results of radiographic examination shall be recorded on a standard reporting form which shall be countersigned by the NPCIL Quality Surveyor on completion of his examination.

i) For each joint there shall be a record attesting that work was completed, examined and found to comply with all the work requirements of this specification.

NOTE: - Mill test certificates for base the materials shall be submitted along with Construction Completion Certificate.

22.2 The above records shall be submitted in quantities as described in the contract documents. Where only a single copy exists such as radiographs and heat treatment record charts, these shall become the property of NPCIL on completion of the contract or earlier if so directed by the Engineer-in-Charge.

23.0 PRE-SERVICE EXAMINATION

Selected weld joints of piping systems shall be subjected to PSI in accordance with the NPCIL procedure no.PP-P-2009(Procedure for UT Examination of pressure retaining welds-steel piping and vessel butt joints).Weld edge preparation & finished weld shall be as per NB 4250 (Fig.No.NB4250-2 or fig no. NB4250-3). Other fabrication requirements shall be as per NB 4424.2.

The PSI requirements are to be worked out before start of piping job.

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RADIOGRAPHIC EXAMINATION OF WELDED JOINTS

Radiographic examination shall meet requirements of Clause 5000 of ASME section III NB/NC/ND as applicable. The rules contained herein describe radiographic examination methods and shall be employed whenever radiographic examination is specified.

1. EQUIPMENT AND MATERIALS

1.1 Radiation Sources

X-ray equipment and radio-active isotopes are required as radiation sources.

1.2 Films

The films shall conform with type 1 or 2 of ASME-SE-94. Standard practice for Radiographic Testing Film characteristics are shown below :-

Film Type	Speed	Contrast	Graininess
1	Low	Very high	Very Low
2	Medium	High	Low

1.3 Screens

1) Intensifying screens may be used, except that flourescent type screens shall not be used. Screens shall be of commercially available types made of pure lead or any alloy of 6% antimony and 94% lead. (Provided the alloying element is uniformly distributed throughout the metal).

2) Screens shall be free from surfaces streaks of lower atomic number materials and from wrinkles, dirt, grease, lint and scratches. Screens showing evidence of physical damage shall be discarded.

3) Screens shall be in intimate contact with both sides of the film during exposure.

1.4 Filters

Objectionable scatter-radiation shall be reduced by suitable filtration with lead foil screens or other high atomic number metals placed between the radiation source and the specimen and between the specimen and film.

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1.5 Penetrameters

1) Penetrameters for radiography of welds shall be fabricated from material that is radiographically similar to or radiographically less dense than the base material and/or the weld metal on which they are used. Radiographically similar material refers to materials or alloys which have approximately the same radiation absorbtion as the material being radiographed. The identical alloy, by chemical analysis, is not usually required. For example, carbon and most alloy steels are considered to be radiographically similar materials but radiographically less dense than materials such as copper or nickel base alloys.

2) The selection and placement of Penetrameters shall be in accordance with ASME-SE-142. The design of penetrameters shall be as indicated in figure no. 1 of ASME (Page 37 of 73) SE-142.

3) Penetrameters shall be identified by permanently attached lead numbers atleast 2.5mm high indicating penetrameter nos. as per table of ASME-SE-142.

1.6 Film Viewing Facilities

Viewing facilities should be constructed as to provide subdued lighting and exclude background lighting of an intensity that may cause reflection of the radiographic film. Equipment used to view films for radiographic interpretation shall provide a high intensity light source such that the proper penetrameter and hole for the specified quality level shall be readily visible for the specified density range. The extraneous light from the illuminator shall be masked. Densitometers or comparison step wedge films shall be provided for assuring compliance with film density requirements. Calibration step wedge films shall be available for checking calibration if densitometers are used.

1.7 Processing Films and Viewing & Storing Radiographs

All films shall be processed in accordance with part-III of ASME-SE-94.

2. TECHNIQUE FOR RADIOGRAPHIC EXAMINATION OF FIELD JOINTS

2.1 Weld Surface Condition

The weld ripples or weld surface irregularities, on both the inside and outside where accessible, shall be removed by any suitable mechanical process to such a degree that the resulting radiographic image due to any irregularities cannot mask or be confused with the image of any discontinuity (see also para 9.0 of the specification).

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2.2 Radiography Quality Level

Radiography shall be performed with a technique of sufficient sensitivity to display the penetrameter and the specified hole which are essential indications of the image quality of the radiograph. Radiograph shall also display the identifying nos. and letters. Essential hole size and thickness of penetrameters shall be as per table NB-5111-1 of ASME Section III. (Table A-2 of this specification)- for the systems meeting the requirements of section III NB and NC.

Table -T276 of ASME Section V for essential hole and thickness of penetrameters (Table A-3 of this specification) is applicable for the systems covered under section III, ND and other systems.

2.3 Radiographic Technique

2.3.1 Single wall technique

In a Single-Wall technique the radiation passes through only one wall of the weld (material) which is viewed for acceptance on the radiograph. An adequate number of exposures shall be made to demonstrate that the required coverage has been obtained.

2.3.2 Double wall technique

When it is not practical to use a single wall technique, one of the following double wall techniques shall be used.

2.3.2.1 Single wall viewing

For materials and for welds in components, a technique may be used in which the radiation passes through two walls and only the weld (material) on the film side is viewed for acceptance, An adequate number of exposures shall be made to demonstrate that the required coverage has been obtained. When complete coverage is required for circumferential welds (materials), a minimum of three exposures taken 120 deg. to each other shall be made.

2.3.2.2 Double wall viewing

For materials and for welds in components 101.60 mm (3 ½ inch) or less in nominal outside diameter, a technique may be used in which the radiation passes through two walls and the weld (material) in both walls is viewed for acceptance on the same radiograph. The penetrameter shall be placed on the source side. Care should be exercised to ensure that the required geometric unsharpness is not exceeded. If the geometric unsharpness requirement cannot be met, then the single wall viewing shall be used.

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2.3.2.2. (a) For welds the radiation beam may be offset from the plane of the weld at an angle sufficient to separate the images of the source side and film side portion of the weld so that there is no overlap of the areas to be interpreted. When complete coverage is required, a minimum of two exposures taken 90 deg. to each other shall be made for each joint.

(b) As an alternative the weld may be radiographed with the radiation beam positioned so that the image of both walls is superimposed. When complete coverage is required a minimum of three exposures taken at either 60 deg. or 120 deg. to each other shall be made for each joint.

(c) Additional exposures shall be made if the required radiographic coverage cannot be obtained using the minimum number of exposures indicated in 2.3.2.2(a) or 2.3.2.2(b) above.

2.4 Penetrameter Application

(1) In addition to the requirements stated in sub-paragraphs 1.5 and 2.2 of this appendix the following shall apply:

a) The penetrameter designation, thickness and hole diameter shall be as per table A1& A2 of this Appendix.

b) The designation of penetrameter for a given weld thickness shall be in accordance with table A2/A3 of this appendix

c) Penetrameter placement for welds shall be in accordance with guideline given in table A4 and A5 of this appendix.

d) The radiographic quality shall be evaluated by the image of a properly located penetrameter.

e) As a rule the penetrameter shall be placed on the side nearest the radiation source. Where it is physically impossible to do this, the penetrameter can be placed on the film side of the joint but it's thickness shall be as shown in table no. A2 and a lead letter "F" as high as penetrameter identification number shall be placed adjacent to or on the penetrameter, but shall not mask the essential hole.

f) Atleast one penetrameter shall be used for each exposure, to be placed so that the plane of the penetrameter is generally normal to the radiation beam. Additional penetrameters on circumferential welds shall be used in accordance with the guideline in table A4 and A5 of this appendix.

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Each penetrameter shall represent an area of essentially uniform radiographic density as judged by density comparison strips or a densitometer. If the film density through the weld varies by more than minus 15 or plus 30 percent from the density through the body of the penetrameter, then an additional penetrameter is required for each exceptional area or areas. If the requirements of subparagraph 2.2 are met by using more than one penetrameter, one shall be representative of the lightest area of a film, and the other in the darkest, the intervening densities on the film shall be considered acceptable. It is not necessary that these additional penetrameters be normal to the radiation source at their location. The film density through acceptable weld metal shall be 1.8 minimum for single film viewing for radiography made with an X-ray source and 2.0 minimum for radiography made with a gamma-ray source. For composite viewing of multiple film exposures, each radiograph of a composite set shall have a minimum density of 1.3. The maximum density shall be 4.0 for either single or composite viewing. A tolerance of 0.05 in density is allowed for variations between densitometer readings.

g) For welds, the penetrameter (s) may be placed adjacent to or on the weld. The identification number(s) and the lead letter "F", when used, shall not be in the area of interest. When geometric configuration makes it impractical to place the penetrameter(s) as mentioned above, or when the weld metal is not radiographically similar to the base material, the identification numbers and lead letter "F" may be placed in the area of interest.

h) A shim of material radiographically similar to the weld metal shall be placed under the penetrameter if needed, so that the radiographic density throughout the area of interest is no more than minus 15% from (lighter than) the radiographic density through the penetrameter.

The shim dimensions shall exceed the penetrameter dimensions such that the outline of at least three sides of the penetrameter image shall be visible in the radiograph.

i) Where more than one film per exposure is used, a penetrameter image shall appear on each film except where the source is placed on the axis of the object and the complete circumference is radiographed with a single exposure at least three uniformly spaced penetrameters shall be employed.

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j) When radiation passes through one or two walls and it is impractical to place the penetrameter inside the pipe the penetrameter may be placed on the film side and appropriate penetrameters from table A2/A3 shall be chosen.

2.5 Film Quality Requirements

All radiographs shall be free from mechanical, chemical or other blemishes to the extent that they cannot mask or be confused with the image of any discontinuity in the area of interest of the object being radiographed. Such blemishes include but are not limited to:-

a) Fogging

b) Processing defects such as streaks, water marks or chemical stains.

c) Scratches, finger marks, crimps, dirtiness, static marks, smudges or tears.

d) Loss of detail due to poor screen to film contact

e) False indications due to defective screens or internal faults.

2.6 Location Markers

1) Location markers, the images of which will appear on the film shall be placed adjacent to the weld on the part, not on the film or film holder, and their locations shall be marked on the surface near the weld in such a manner that a defect appearing on a radiograph may be accurately located and in such a manner that it is evident on the film that complete coverage of the weld has been obtained.

2) Location markers as indicated in ASME Section V Fig-T-275 are shown in page 46.

3) Radiographs shall include all the information shown in the sketch on page 47.

2.7 Source to Film Distance

Geometric unsharpness of the radiograph shall be determined in accordance with :

$$Ug = \frac{Fd}{D}$$

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Where,

U_g = Geometric unsharpness

F = Source size, in mm, the maximum projected dimension of the radiation source (or focal spot) in the plane perpendicular to the distance D from the weld or object being radiographed.

D = Distance in mm from source of radiation to weld or object being radiographed.

d = Distance in mm from source side of weld or object being radiographed to the film.

Geometric unsharpness of the radiograph shall not exceed the following:-

Material thickness mm	U_g maximum in mm
Under 50	0.510
50 through 75	0.760
Over 75 through 100	1.020
Greater than100	1.780

Material thickness is the thickness on which the penetrameter is based.

2.8 Object to Film Distance

The object to film distance shall be the minimum possible and when practical the film shall be shaped to the contour of the object.

3. PROCEDURE REQUIREMENTS

Radiographic examination shall be performed in accordance with a written procedure to the requirements listed below

a) The type of material to be radiographed;
b) The material thickness ranges to be radiographed;
c) The type of radiation source, maximum focal spot or source size, X-ray machine voltage rating and manufacturer;
d) Film brand and type and number of films in cassette. For multiple film technique state whether viewing will be done with superimposed films;
e) Type and thickness of intensifying screens and filters;
f) Blocking or masking technique, if any
g) Minimum source to film distance
h) Exposure conditions, voltage, distance of film to object, geometric arrangements for the radiographs. (Shooting sketch) Orientation of location markers;
i) Description of the welding procedure or approved welding procedure number.

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4. REPORTS

Written reports of radiographic examination shall be submitted for the approval of the Quality Surveyor in the form, approved by the Engineer/ Quality Surveyor. Prior to submitting above reports to the Engineers/Quality Surveyor, radiographs shall be examined and interpreted by the contractor and the written reports shall be accompanied by such review reports.

TABLE A1

PENETRAMETER DESIGNATION, THICKNESS AND HOLE DIAMETERS

(Unbracketed dimensions are in mm, bracketed dimensions are in inches)

Penetrameter Designation	Penetrameter Thickness	1T Hole Diameter	2T Hole Diameter	4T Hole Diameter
5	0.14	0.25	0.50	1.00
	(0.005)	(0.010)	(0.020)	(0.040)
7	0.18	0.25	0.50	1.00
	(0.007)	(0.010)	(0.020)	(0.040)
10	0.25	0.25	0.50	1.00
	(0.010)	(0.010)	(0.020)	(0.040)
12	0.30	0.30	0.64	1.20
	(0.012)	(0.012)	(0.025)	(0.050)
15	0.38	0.38	0.70	1.52
	(0.015)	(0.015)	(0.030)	(.060)
17	0.43	0.43	0.86	1.72
	(0.017)	(0.017)	(0.035)	(0.070)
20	0.51	0.51	1.02	2.04
	(0.020)	(0.020)	(0.040)	(0.080)
25	0.64	0.64	1.28	2.56
	(0.025)	(0.025)	(0.050)	(0.100)
30	0.76	0.76	1.52	3.04
	(0.030)	(0.030)	(0.060)	(0.120)
35	0.89	0.89	1.78	3.56
	(0.035)	(0.035)	(0.070)	(0.140)
40	1.02	1.02	2.04	4.08
	(0.040)	(0.040)	(0.080)	(0.160)
45	1.14	1.14	2.28	4.56
	(0.045)	(0.045)	(0.090)	(0.180)
50	1.27	1.27	2.54	5.08
	(0.050)	(0.050)	(0.100)	(0.200)

APPENDIX – A – CONTD.....

TABLE A1

PENETRAMETER DESIGNATION, THICKNESS AND HOLE DIAMETERS

(Unbracketed dimensions are in mm, bracketed dimensions are in inches)

Penetrameter Designation	Penetrameter Thickness	1T Hole Diameter	2T Hole Diameter	4T Hole Diameter
60	1.52	1.52	3.04	6.08
	(0.060)	(0.060)	(0.120)	(0.240)
80	2.03	2.03	4.06	8.12
	(0.080)	(0.080)	(0.160)	(0.320)
100	2.54	2.54	5.08	10.16
	(0.100)	(0.100)	(0.200)	(0.400)
120	3.05	3.05	6.10	12.20
	(0.120)	(0.120)	(0.240)	(0.480)
160	4.06	4.06	8.12	16.24
	(0.160)	(0.160)	(0.320)	(0.640)
200	5.08	5.08	10.16	20.32
	(0.200)	(0.200)	(0.400)	(0.800)

APPENDIX – A – CONTD.....

TABLE A2 TABLE NB 5111-1 TABLE NC 5111-1

MATERIAL THICKNESS, PENETRAMETER DESIGNATIONS AND ESSENTIAL HOLES

FOR SYSTEMS COVERED UNDER ASME SECTION III NB AND NC.

MATERIAL THICKNESS RANGE IN MM	PENETRAMETER			
	SOURCE SIDE		FILM SIDE	
	DESIGNATION	ESSENTIAL HOLE	DESIGNATION	ESSENTIAL HOLE
UPTO 6 INCL.	5	4T	5	4T
OVER 6 THROUGH 10	7	4T	7	4T
OVER 10 THROUGH 12	10	4T	10	4T
OVER 12 THROUGH 16	12	4T	12	4T
OVER 16 THROUGH 19	15	4T	12	4T
OVER 19 THROUGH 22	17	4T	15	4T
OVER 22 THROUGH 25	20	2T	15	2T
OVER 25 THROUGH 31	25	2T	17	2T
OVER 31 THROUGH 38	30	2T	20	2T
OVER 38 THROUGH 50	35	2T	25	2T
OVER 50 THROUGH 63	40	2T	30	2T
OVER 63 THROUGH 75	45	2T	35	2T
OVER 75 THROUGH 100	50	2T	40	2T
OVER 100 THROUGH 150	60	2T	45	2T
OVER 150 THROUGH 200	80	2T	50	2T
OVER 200 THROUGH 250	100	2T	60	2T
OVER 250 THROUGH 300	120	2T	80	2T
OVER 300 THROUGH 400	160	2T	100	2T
OVER 400 THROUGH 500	200	2T	120	2T

NOTE 1: FOR ANY MATERIAL THICKNESS RANGE, THE USE OF PENETRAMETER DESIGNATION OR THICKNESS LESS THAN LISTED IN THE TABLE ABOVE FOR THAT RANGE WILL ALSO BE ACCEPTABLE PROVIDED ALL THE OTHER REQUIREMENTS FOR THE RADIOGRAPHY ARE MET. FOR WELDS, THE THICKNESS RANGE IS THE SINGLE WALL THICKNESS INCLUDING REINFORCEMENTS.

NOTE 2: REFER TABLE A1 OF THIS APPENDIX FOR PENETRAMETER DESIGNATION, THICKNESS & HOLE DIAMETERS.

APPENDIX – A – CONTD.....

TABLE - A3

SPECIFICATION : TABLE - ASME SECTION V-T-276

MATERIAL THICKNESS, PENETRAMETER DESIGNATIONS AND ESSENTIAL HOLES

FOR SYSTEMS COVER ASME SECTION III ND AND OTHER SYSTEMS

NOMINAL SINGLE WALL MATERIAL THICKNESS RANGE IN INCH.	PENETRAMETER			
	SOURCE SIDE		FILM SIDE	
	DESIGNATION	ESSENTIAL HOLE	DESIGNATION	ESSENTIAL HOLE
UPTO 0.25 INCL.	10	4T	7	4T
OVER 0.25 THROUGH 0.375	12	4T	10	4T
OVER 0.375 THROUGH 0.50	15	4T	12	4T
OVER 0.50 THROUGH 0.625	15	4T	12	4T
OVER 0.625 THROUGH 0.75	17	4T	15	4T
OVER 0.75 THROUGH 0.875	20	4T	17	4T
OVER 0.875 THROUGH 1.00	20	4T	17	4T
OVER 1.00 THROUGH 1.25	25	4T	20	4T
OVER 1.25 THROUGH 1.50	30	2T	25	2T
OVER 1.50 THROUGH 2.00	35	2T	30	2T
OVER 2.00 THROUGH 2.50	40	2T	35	2T
OVER 2.50 THROUGH 3.00	45	2T	40	2T
OVER 3.00 THROUGH 4.00	50	2T	45	2T
OVER 4.00 THROUGH 6.00	60	2T	50	2T
OVER 6.00 THROUGH 8.00	80	2T	60	2T
OVER 8.00 THROUGH 10.00	100	2T	80	2T
OVER 10.00 THROUGH 12.00	120	2T	100	2T
OVER 12.00 THROUGH 16.00	160	2T	120	2T
OVER 16.00 THROUGH 20.00	200	2T	160	2T

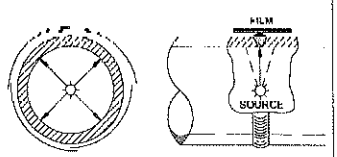
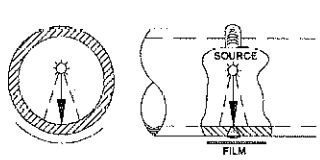
NOTE 1: FOR ANY MATERIAL THICKNESS RANGE, THE USE OF PENETRAMETER DESIGNATION OR THICKNESS LESS THAN LISTED IN THE TABLE ABOVE FOR THAT RANGE WILL ALSO BE ACCEPTABLE PROVIDED ALL THE OTHER REQUIREMENTS FOR THE RADIOGRAPHY ARE MET. FOR WELDS, THE THICKNESS RANGE IS THE SINGLE WALL THICKNESS INCLUDING REINFORCEMENTS.

NOTE 2: REFER TABLE A1 OF THIS APPENDIX FOR PENETRAMETER DESIGNATION, THICKNESS & HOLE DIAMETERS.

APPENDIX - A CONTD....

TABLE - A-4 REPRODUCED FROM ARTICLE 2. APPENDIX A OF ASME SECT. V

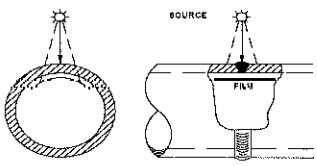
SINGLE WALL RADIOGRAPHIC TECHNIQUES

PIPE O.D.	EXPOSURE TECHNIQUE	RADIOGRAPH VIEWING	SOURCE - WELD - FILM ARRANGEMENT		IQI PENETRAMETER		LOCATION
			END VIEW	SIDE VIEW	SELECTION	PLACEMENT	
ANY	SINGLE WALL PARA 2.3.1	SINGLE WALL	 EXPOSURE ARRANGEMENT - A		SINGLE WALL PARA. 2.4 AND TABLE A-2 / A-3	SOURCE SIDE PARA. 2.4 FILM SIDE PARA. 2.4	EITHER SIDE T - 275.3 T - 275.1 (c) OF ASME SEC - V
ANY	SINGLE WALL PARA. 2.3.1	SINGLE WALL	 EXPOSURE ARRANGEMENT - B		SINGLE WALL PARA. 2.4 AND TABLE A-2 / A-3	SOURCE SIDE PARA. 2.4 FILM SIDE PARA. 2.4	EITHER SIDE T - 275.1 (c) OF ASME SEC - V

APPENDEIX - A (CONTD)

TABLE - A-4 (CONTD:) REPRODUCED FROM ARTICLE 2. APPENDIX A OF ASME SECT. V

SINGLE WALL RADIOGRAPHIC TECHNIQUES

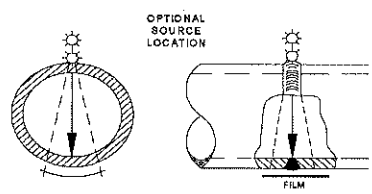
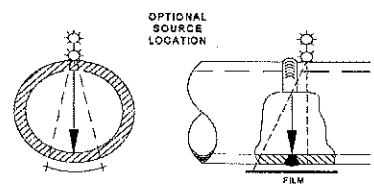
PIPE O.D.	EXPOSURE TECHNIQUE	RADIOGRAPH VIEWING	SOURCE - WELD - FILM ARRANGEMENT		IQI PENETRAMETER		LOCATION
			END VIEW	SIDE VIEW	SELECTION	PLACEMENT	
ANY	SINGLE WALL PARA 2.3.1	SINGLE WALL	 EXPOSURE ARRANGEMENT- C		T - 276 AND TABLE T - 276	SOURCE SIDE PARA. 2.4 FILM SIDE PARA. 2.4	

THE ABOVE SKETCHES ARE SUGGESTED TECHNIQUES. OTHER EXPOSURE ARRANGMENT MAY BE MADE PROVIDED, THEY COMPLY WITH REQUIREMENT OF PARA 2.0 OF THIS APPENDIX.

APPENDIX - A CONTD....

TABLE - A-5 REPRODUCED FROM ARTICLE 2. APPENDIX A OF ASME SECT. V

DOUBLE WALL RADIOGRAPHIC TECHNIQUES

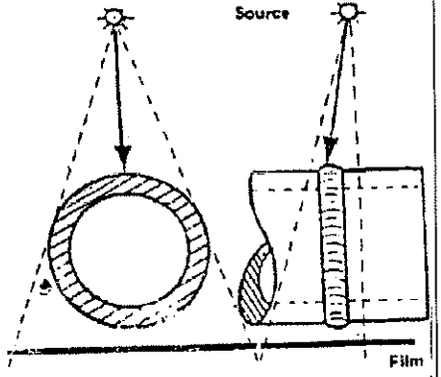
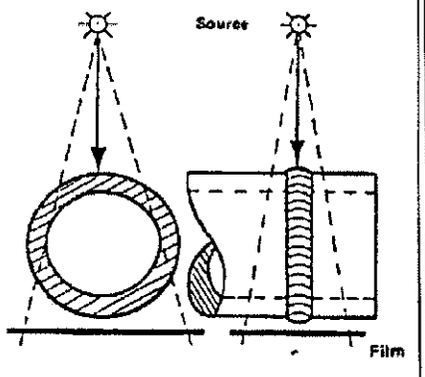
PIPE O.D.	EXPOSURE TECHNIQUE	RADIOGRAPH VIEWING	SOURCE - WELD - FILM ARRANGEMENT		IQI PENETRAMETER		LOCATION
			END VIEW	SIDE VIEW	SELECTION	PLACEMENT	
ANY	DOUBLE WALL AT LEAST 3 EXPOSURES 120° TO EACH OTHER FOR COMPLETE COVERAGE PARA . 2.3.2.1	SINGLE WALL	 EXPOSURE ARRANGEMENT - D		T - 276 AND TABLE T - 276 A-2 / A-3	PARA. 2.4 AND TABLE A-2 / A-3	SOURCE SIDE T- 277.1 (A) OF ASME SEC. V FILM SIDE T- 277.1 (A) OF ASME SEC. V
ANY	DOUBLE WALL AT LEAST 3 EXPOSURES 120° TO EACH OTHER FOR COMPLETE COVERAGE PARA . 2.3.2.1	SINGLE WALL	 EXPOSURE ARRANGEMENT - E				

APPENDIX – A – CONTD.....

TABLE A5

TABLE- A-5 (Contd) Reproduced from Article 2, Appendix A of ASME Sect.V

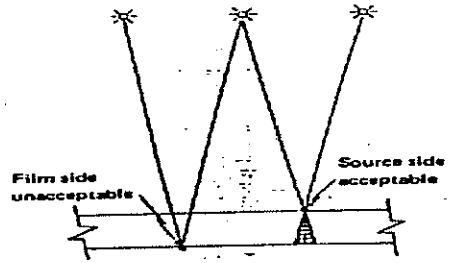
DOUBLE WALL RADIOGRAPHIC TECHNIQUES

Pipe O.D.	Exposure technique	Radiograph viewing	Source-weld-film arrangement		IQI Penetrameter		Location
			End view	Side view	Selection	Placement	
3 ½ Inch or less	Double wall At least 2 exposures 90 deg. To each other for complete coverage Para. 2.3.2.2 (A)	Double wall (Ellipse) read offset Source side and film side images	 Exposure Arrangement - F		Single wall	Para2.4 and table A-2/ A-3	Source side T-277.1 (A) of ASME sec-V
3 ½ Inch Or less	Double wall At least 3 exposures 60° or 120° to each other for complete coverage Para. 2.3.2.2 (B) .	Double wall read super imposed source side and film side images	 Exposure Arrangement - G		Single wall	Para2.4 and table A-2/ A-3	Source side T-277.1 (A) of ASME sec-V Film side T-277.1 (A) of ASME sec-V

This above sketches are suggested techniques. Other exposure arrangement may be made provided, they comply with requirements of para 2.0 of this appendix.

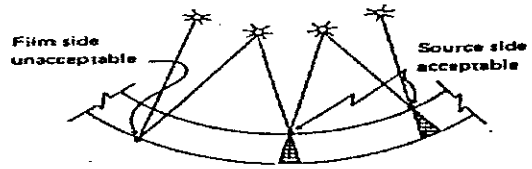
APPENDIX – A (contd)

LOCATION MARKER SKETCHES (Reproduced from sketch T-275 of ASME Sect.V)



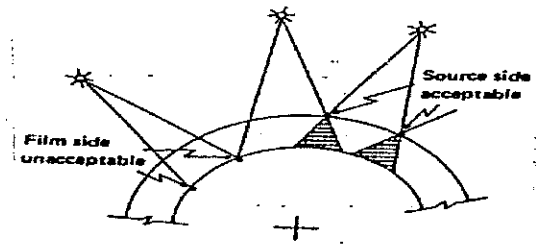
(a)

Flat Component or longitudinal seam (See T-275.1(a)(1) of ASME Sec-V (see sketch (e) for alternate)



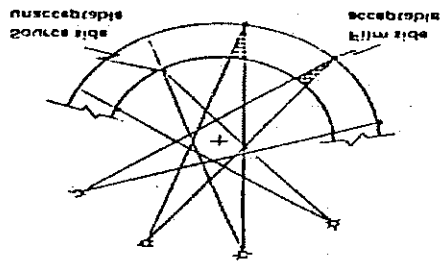
(b)

Curved components with radiation source to film distance less than radius component (seeT275.1(a)(2) of ASME Sec.V)



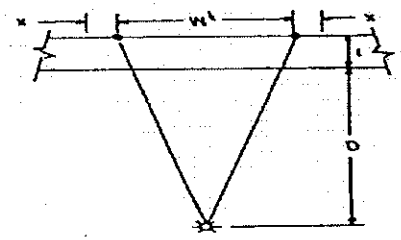
(c)

Curved components with convex surface towards Radiation sourc (see T-275.1(a)(3) of ASME sec.V)



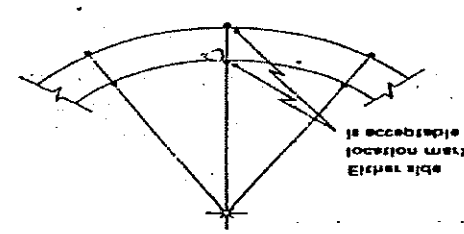
(d)

Curved components with radiation source to Film distance greater than radius of curvature (see T-275.1(b)(I) of ASME Sec.V) LEGEND : Radiation Source o Location marked * Component centre +



(e)

Source side marker alternate. Flat components or longitudenal seam X = (t/D)(Mf)/2 x = additional required coverage, in beyond film side location marker t = Component thickness in. Mf = film side location marker interval in, D = Source to component distanmce in. (see T-275.1(b)(2) of ASME Sec V



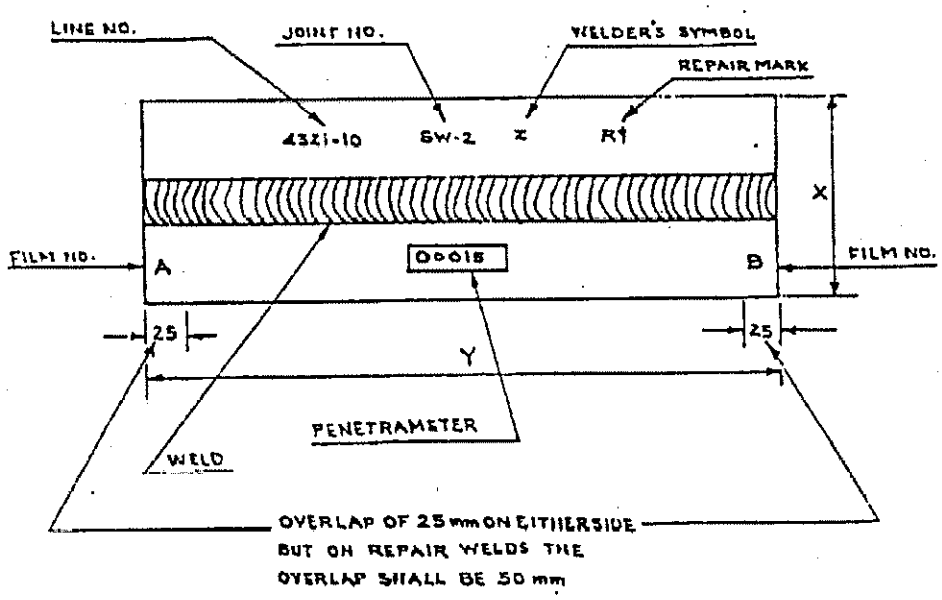
(f)

Curved components with radiation source At centre curvature (see T-275.1(c) of ASME Sec.V)

APPENDIX – A (Contd...)

FILM IDENTIFICATION

(TYPICAL EXAMPLE)



X = FILM WIDTH

Y = FILM LENGTH

APPENDIX – B

MAGNETIC PARTICLE EXAMINATION

The rules contained herein describe magnetic particle examination methods which shall be employed whenever magnetic particle examination is specified. The rules are substantially in accordance with Article 7 of ASME Section V, and generally conform to SE-709. "Standard Recommended practice for Magnetic Particle Examination", and reference to this standard may be made for additional details to be included in the written procedures required herein.

1. GENERAL

Magnetic particle examination provides for the detection of rounded discontinuities, cracks and other linear discontinuities in welds, plates, forgings, tubular products and castings. Sensitivity is greatest for surface defects and diminishes rapidly with depth below the surfaces. Magnetic particle examination is applicable only to ferromagnetic materials.

1.1 Surface Preparation

The surface to be examined, and all adjacent areas with in at least 25 mm including the surface to which electrical or magnetic connections are to be made, shall be clean and dry and shall be free from oil, grease, sand, loose-rust, or scale. Preparation of as rolled, as cast or as forged materials by grinding or machining is required when surface irregularities would mask indications of defects.

1.2 Description of Methods

This method of examination consists of magnetizing the area to be inspected to near saturation and then applying the examination medium to the surface. The particles will be retained on the surface, at cracks, and other discontinuities, due to leakage in the magnetic field. The patterns will be characteristics of the type of defect present.

1.3 Sequence of Operation

Examination shall be carried out by the continuous method, that is, the magnetizing current shall remain on during the period the examination medium is being applied and also while excess examination medium is being removed.

1.4 Examination Medium

The color of the ferromagnetic particles (dry powder) shall be such as to provide adequate contrast with the background of the surface being examined. Additional details on the use of dry particles are given in SE-709 "standard recommended practice for magnetic particle examination".

APPENDIX – B – CONTD.....

1.5 Orientation of Defects

Regardless of the manner of producing the magnetic flux, the greatest sensitivity will be to the linear defects lying perpendicular to the lines of flux. Hence, to ensure most effective detection of defects, it is necessary to examine each area at least twice with the lines of flux in one case approximately perpendicular to the lines of flux in the other.

1.6 Examination Coverage

Examination shall be conducted with sufficient overlap to assure 100% coverage at the required sensitivity.

1.7 Demagnetization

Demagnetization following examination is required where residual magnetism interferes with subsequent processes or usage.

2.0 METHODS

2.1 Prod Method

a) Magnetizing Technique

Magnetization is accomplished by the use of portable prod-type electrical contacts pressed against the surface in the area to be examined. A remote control switch, which may be built into the prod handles, shall be provided to permit the operator to turn the current on after the prods have been properly positioned and to turn it off before the prods are removed in order to prevent arcing.

b) Prod Spacing

Prod spacing shall be maximum of 200 mm. Shorter spacing may be used to meet the geometry of the area being examined or to increase sensitivity but prod spacing less than 75 mm usually is not feasible due to banding of particles around the prods.

Care shall be taken to prevent local overheating or burning of the surface examined. Lead, steel or aluminum (rather than copper tipped prods) are recommended where the magnetizing voltage is over 25 volts open circuit in order to avoid copper deposits.

APPENDIX – B– CONTD.....

c) Magnetizing Current

Direct or rectified magnetizing current shall be used. The current shall be 40 (minimum) to 50 (maximum) amperes per cm of prod spacing for section 20 mm thick or greater. For sections less than (20 mm) thick, the current shall be 35 to 43 amperes per cm.

d) Direction of Magnetization

Atleast two separate examinations shall be carried out on each area. The prods shall be placed so that the lines of flux during one examination are approximately perpendicular to the lines of flux during the other.

2.2 Other Methods

Other methods of magnetizing technique may be used but shall require specific approval of the Quality Surveyor.

3.0 EVLUATION OF INDICATIONS

3.1 Defects which occur as mechanical discontinuities at the surface will be indicated by the retention of the examination medium. All indications are not necessarily defects, however, since certain metallurgical discontinuities and magnetic permeability variations may produce similar indications which are not relevant to the detection of defects.

3.2 Any indication which is believed to be non-relevant shall be regarded as a defect until the indication is either eliminated by surface conditioning or it is demonstrated to be non-relevant. Non-relevant indications which would mask indications of defects are unacceptable.

3.3 Relevant indications are those which result from mechanical discontinuities. Linear indications are those indications in which the length is equal or more than three times the width. Rounded indications are those which are circular or elliptical with the length less than three times the width.

4.0 REPAIR OF DEFECTS

All repairs shall be made in accordance with the requirements of the applicable paragraphs (12.0) in this specification for the particular product form, including welds. Whenever a defect is removed and subsequent welding is not required, the affected area shall be blended into the surrounding surface so as to avoid sharp notches.

APPENDIX – B– CONTD.....

5.0 PROCEDURE REQUIREMENTS

Magnetic particle examination shall be performed in accordance with a written procedure. As a guide, review of procedural information included in SE-709 is suggested. The contractor shall certify that the procedure is in accordance with the requirement of this Appendix and shall make the procedure available to the Engineer-in-Charge for approval.

Each examination procedure shall include at least the following information:

a) Materials, shapes or sizes to be tested;
b) Type of magnetization to be used;
c) Equipments to be used for magnetization;
d) Surface preparation (finishing and cleaning);
e) Ferro magnetic particles to be used, manufacturer and color;
f) Magnetization current;
g) Demagnetization;
h) Sketches or a chart indicating coverage, where necessary for clarity.

APPENDIX – C

LIQUID PENETRANT EXAMINATION

The rules contained herein describe methods that shall be employed whenever liquid penetrant examination is specified. The rules are substantially in accordance with articles of ASME Section V and generally conform to SE-165 "Standard Practice for Liquid Penetrant Inspection Method" and reference to this Standard may be made for additional details to be included in written procedures required herein.

1.0 DESCRIPTION OF METHOD

Liquid penetrant examination is a method of nondestructive examination which provides for the detection of discontinuities open to the surface in ferrous and non-ferrous materials which are non-porous. Typical discontinuities detectable by this method are cracks, seams, laps, cold shuts and laminations. A liquid penetrant is applied to the surface to be examined and allowed to enter such openings. Then the excess penetrant is removed, the part is dried, and a developer is applied which is wetted or otherwise affected by the penetrant entrapped in the discontinuities. This increases the evidence of the dis-continuities so that they may be seen.

2.0 APPROVED METHODS

a) Since the major use of liquid penetrant examination will be on field erected piping, only the visible dye penetrant-solvent removable method is specified. Other methods shall require the specific approval of the Quality Surveyor.

b) In order to avoid stress corrosion, the halogen and sulphur contents, of the various agents used in liquid penetrant testing, shall be restricted to 25 ppm in the solution at the concentration used in the examination.

3.0 METHOD REQUIREMENTS

3.1 Surface Preparation

a) In general satisfactory result may be obtained when the surface is in the as-welded, as-rolled, as-cast, or as-forged condition. When surface irregularities mask the indication of defects, grinding or machining of the surface will be required.

b) Prior to liquid penetrant examination, the surface to be tested and any adjacent area within at least 25mm of the surface to be tested shall be dry and free of any dirt, grease, lint, scale, welding flux, spatter, oil or any extraneous matter that would obscure surface openings or otherwise interfere with the test.

APPENDIX – C– CONTD.....

c) Typical cleaning agents which may be used for removing contaminants are detergents, organic solvents, descaling solutions, and paint removers. Vapour degreasing and ultrasonic cleaning methods may also be used. Cleaning solvents shall meet the requirements or NPC specification PP-P-550. The cleaning method employed is an important part of the test procedure. (The above cleaning agents shall not be confused with the penetrant remover which is a special fluid and which shall also require approval).

3.2 Drying

Drying of the surface to be tested, after cleaning, can be accomplished by normal evaporation. A minimum period of time shall be established and included in the written procedure to assure that the cleaning solvents have evaporated prior to the application of the penetrant. When employing the non-volatile solvent, it is recommended that forced hot air be used to accelerate drying.

3.3 Penetrant Application

1) The penetrant shall be applied by dipping, brushing, or spraying. If the penetrant is applied by spraying using compressed air type apparatus, filters shall be placed at the air inlet to preclude contamination of the penetrant from oil, water and dirt sediment that may have collected in the lines.

2) Penetrant time is critical. The minimum penetrations time shall be as recommended in SE-165, Table 2 or as qualified by demonstration for specific applications.

3) As a standard technique, the temperature of the surface of the part to be processed shall not be below 16 deg. C nor above 52 deg. C, throughout the examination period. Local heating or cooling is permitted provided temperatures remain in the range of 16-52 deg. C during the examination. Where it is impracticable to comply with the foregoing temperature limitations, other temperatures and times may be used provided that the procedure is qualified as described in paragraph 5.2.

4) If penetrant characteristics are materially affected by a prolonged dwell time, as evidenced by difficulty in removing the excess, penetrant shall be reapplied for the original prescribed dwell time.

APPENDIX – C– CONTD.....

3.4 Excess Penetrant Removal

Guidelines given in Para 6.5 of SE 165 shall be followed.

1) After the penetrant time specified in the procedure has elapsed, any penetrant remaining on the surface shall be removed.

2) Excess penetrant, in so far as possible, shall be removed by using clean, dry cloths or absorbent paper. The operation should be repeated until most traces of penetrant have been removed. A clean dry cloth or absorbent paper shall then be moistened, with solvent and the surface shall be wiped lightly until all remaining traces of excess penetrant have been removed. Care shall be employed not to use an excess of the solvent in order to avoid removing penetrant from the defects. Flushing the surface with solvent following the application of the penetrant and prior to developing is prohibited.

3.5 Developing

1) The developer shall be applied as soon as possible after the penetrant removal operation and the interval shall not exceed the time established during procedure qualifications.

2) The developer is a suspension of powder in water or a volatile solvent and shall be applied by dipping or spraying. Insufficient coatings thickness may not draw the penetrant out of discontinuities. Conversely, excessive coating thickness of developer may mask indications. Prior to applying the liquid developer to the test surface, the developer must be thoroughly agitated to ensure that the particles in suspension are dispersed.

3) The quality of the developer and the method of application in a fine spray are important and shall be demonstrated to the satisfaction of the Quality Surveyor.

4. EXAMINATION

1) The true size and type of discontinuities are difficult to evaluate if the penetrant diffuses excessively in the developer. Consequently, it is good practice to observe the surface during the application of the developer in order to detect the nature of certain indications which might tend to bleed out profusely. Final interpretation, however, shall be made after allowing the penetrant to bleed out for a minimum of seven (7) minutes to a maximum of thirty (30) minutes. If the test surface is sufficiently large to preclude complete testing and examination within the prescribed times, the surface shall be tested and examined in suitable increments.

APPENDIX – C– CONTD.....

2) The developer should form a more or less uniform white coating. Surface discontinuities are indicated by bleeding out of the penetrant which is normally of a deep red colour. Indications which exhibit a light pink colour may indicate excessive or inadequate cleaning.

3) Illumination shall be provided which is adequate to ensure that there is no loss in the sensitivity of the test.

5. QUALIFICATION OF PROCEDURE

5.1 Normal Test Conditions

Required procedures shall be qualified on test pieces representative of the manufacturer's product with respect to material type and product form (weld, casting, wrought product etc.)

5.2 Abnormal Test Conditions

a) When it is impracticable to conduct a liquid penetrant examination within the temperature range of 16-52 deg. C, the examination procedure at the proposed temperature must be qualified. This is accomplished by producing quench cracks in an aluminium block, which for this purpose is designated as a "liquid penetrant comparator" and then examination on section of the block at the proposed temperature and the other section of the block at a temperature in the range of 16-52 deg. C.

b) Liquid Penetrant Comparator

The liquid penetrant comparator shall be made of aluminium SB-211, Type 2024, as rolled, 10mm thick and shall have face dimensions of 50mm X 75mm. At the center of each face, an area approximately 25mm in diameter shall be marked with a 510 deg. C temperature indicating crayon or paint. The marked area shall be heated by a blow torch, a Bunsen burner or a similar device to a temperature of 510 deg. C to 525 deg. C. The specimen is then quenched in cold water to produce a network of fine cracks on each face. The block shall then be dried by heating to 150 deg. C, after which a groove shall be machined across the centre of each face 1.6mm deep and 1.2mm wide. One half of the specimen shall be designated as "A" and the other as "B" for identification in subsequent procedures. The figure on page C-8 shows the Comparator after the grooves have been cut.

APPENDIX – C– CONTD.....

c) Comparator Application

If it is desired to qualify a liquid penetrant examination procedure at a temperature less than 16 deg. C, the proposed procedure shall be applied to area "B" after the block and all testing materials have been cooled to the proposed examination temperature. The block then shall be allowed to warm to a temperature of 16 deg. C to 52 deg. C and area "A' examined in a manner which has been demonstrated to be suitable for use in this temperature range. The indications of cracks shall be compared for areas "A" and "B". If the indications obtained under the proposed conditions are essentially the same as those obtained under the examination at 16 deg. C to 52 deg. C, the proposed procedure may be considered qualified for use.

If the proposed temperature for the examination is above 52 deg. C then only the block need to be held at this temperature through out the examination of the "B" section.

2) If the proposed temperature for the examination is above 52 deg. C, block "B" shall be held at this temperature throughout the examination. The indications of cracks shall be compared as described in 1 above while block "B" is at the proposed temperature and block "A" is at the 16 deg. C to 52 deg. C temperature range.

A procedure qualified at a temperature lower than 16 deg. C shall be qualified from that temperature to 16 deg.C.

To qualify a procedure for temperatures above 52 deg. C, the upper and lower temperature limits shall be established and the procedure qualified at these temperatures.

6. EVALUATION OF INDICATIONS

1) Defects which occur as mechanical discontinuities at the surface will be indicated by bleeding out of the penetrant, however, localized surface imperfections such as may occur from machining marks or surface conditions may produce similar indications which are not relevant to the detection of defects.

2) Any indication which is believed to be non-relevant shall be regarded as defect until the indication is either eliminated by surface conditioning or it is demonstrated to be non-relevant. Non-relevant indications and broad areas of pigmentation which would mask indications of defects are unacceptable.

APPENDIX – C– CONTD.....

3) Relevant indications are those which result from mechanical discontinuities. Linear indications are those indications in which the length is equal or more than three times the width. Rounded indications are indications which are circular or elliptical with the length less than three times the width.

7. REPAIR OF DEFECTS

All repairs shall be made in accordance with the requirements for the particular product form, including welds. Whenever a defect is removed and subsequent welding is not required, the affected area shall be blended into the surrounding surface so as to avoid sharp notches, crevices or corners. Ref. para 12.0 (Page 12) of this Specification.

8. MANUFACTURE'S PROCEDURE

8.1 Procedure Requirements

The contractor shall certify that the required written procedure is in accordance with applicable requirements of this specification. The required written examination procedure shall record in detail atleast the following information:

a) Brand name and specific type (number or letter designation if available) of penetrant, penetrant remover and developer;

b) Details of the method of pretest cleaning and drying including cleaning materials used and time allowed for drying.

c) Details of the method of penetrant application, the length of time that the penetrant remains on the surface and the temperature of the surface and penetrant during the examination if not within 16 deg. C to 52 deg. C range;

d) Details of the method of removing excess penetrant from the surface and of drying the surface before applying the developer;

e) Details of the method of applying the developer and length of developing time before inspection;

f) Method of post-test cleaning.

8.2 Procedure Re-qualification

Requalification is required:

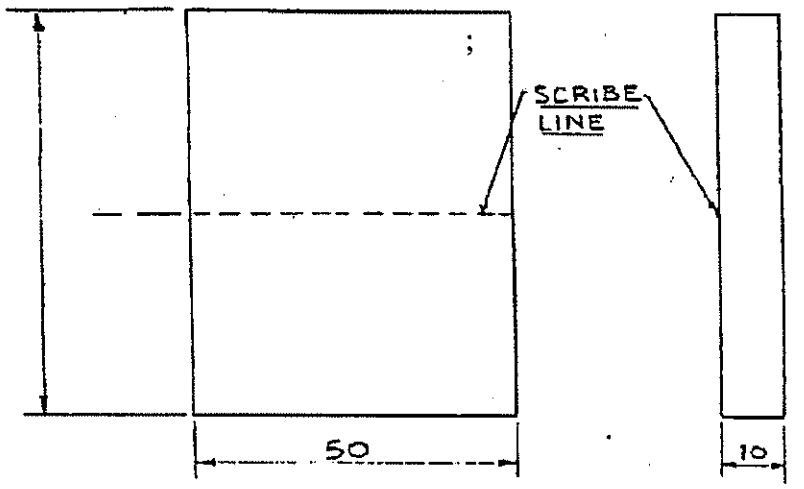
a) When any prior processing which may affect the penetrant test is changed;

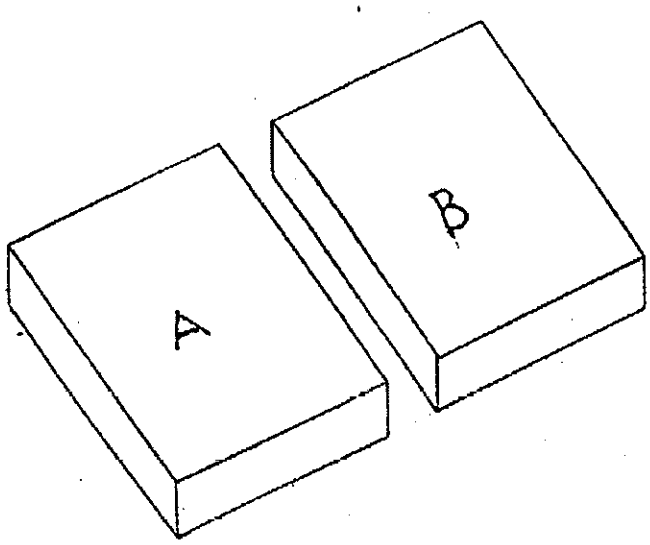
b) When a change or substitution is made in the precleaning materials or methods;

c) When a change or substitution is made in the penetrant material (including developer etc.) or in the processing technique.

APPENDIX – C– CONTD.....

LIQUID PENETRANT COMPERATOR BLOCK





APPENDIX - D

JOINT DESIGN DRAWINGS

I. BUTT WELD END PREPARATION FOR THE USE OF CONSUMABLE INSERTS.

Butt weld pipe fittings, equipment nozzle and valve ends would be supplied conforming to any of the following end preparations.

I.1 Butt weld end preparation for the use of consumable inserts in project piping: As per drawing no NPCIL/01006 /2228 /SK (Latest revision)

I.2 Butt weld end preparation for y-type consumable inserts:
As per drawing no NPCIL/01006/ 2232/SK (Latest revision)

I.3 Butt weld edge preparation for feeder fittings using flat type consumable inserts: As per drawing no NPCIL/01006/2235/SK (Latest revision)

I.4 As per ANSI - B 16.25 – Latest edition.

While welding such fittings/valves/nozzles, relevant joint edge preparation shall be done by the contractor for making the joint. For B.W. joints between pipe to pipe, the contractor may select any of design drawings mentioned against I.1 to I.2 depending on the type of insert chosen.

APPLICATION

a) Primary Heat Transport System including Feeder and Reactor Headers. (I.1, I.2, I.3)
b) Moderator System (I.1)
c) Fuel Transfer System and F/M Valve Station (I.1, I.2)
d) Secondary System Inside Reactor Building.
e) Discharge side of B.F. Pump (Outside Reactor Building). (I.1)
f) All joints inside C.V.
g) Reactor Auxiliary System located in F/M Vaults. (I.1)
h) Other systems wherein butt welding with consumable inserts has been specified.

APPENDIX – D– CONTD.....

II. **WELDING OF INTEGRALLY REINFORCED BRANCH CONNECTIONS LIKE ELBOWLET. LATROLET AND WELDOLET.**

II.1 Welding of integrally re-inforced branch connections like - elbowlet, latrolet and weldolet. Refer drawing no NPCIL/01006/2229/SK (Latest Revision)

APPLICATION

As applicable

III. **DETAILS OF FILLET WELD FOR SOCKET WELDING FITTINGS. FLANGES AND SLIP-ON FLANGES**

III.1 Details of fillet weld for socket welding fittings, flanges & slip on flanges: Refer drawing no NPCIL/01006/2230/SK (Latest revision)

APPLICATION

As applicable

IV. **END PREPARATION FOR BUTT WELDING STEEL PIPING WHERE ROOT PASS IS DONE WITH SMAW.**

IV.1 End prcparation for butt welding steel piping:
Refer drawing no NPCIL/01006/2231/SK (Latest revision)

APPLICATION

For all systems except those covered in (I)

V. **WELDING OF SET-ON AND SET-IN EQUAL BRANCH CONNECTIONS**

V.1 Welding of set-on, set-inequal branch connection joints:
Refer drawing no NPCIL/01006/2233/SK (Latest revision)

APPLICATION

Low pressure (<10 kg/cm. sq. (g) and low temperature (<100 deg. C) piping

VI. **WELDING OF SET-IN AND SET-ON SLOPPING EQUAL BRANCH CONNECTION JOINTS**

VI.1 Welding of set-on, set-in sloping equal branch connection joints: Refer drawing no NPCIL/01006/2234/SK (Latest revision)

APPLICATION

As per (V) above.

APPENDIX – E

GENERAL REVIEW OF MATERIAL SPECIFICATIONS OF NPP PIPING

System	Pipe		Fitting		Valves		Equipment Nozzle		Remarks
	Spec. & Grade	ASME P.No.& Gr.No.	Spec. & Grade	ASME P.No.& Gr. No.	Spec. & Grade	ASME P.No.& Gr. No	Spec. & Grade	ASME P.No. & Gr. No.	
Moderator System (Moderator main system ,auxiliries,SDS# 2&LZC)	SA-312 TP-304L	P8-1	SA-182, F304L	P8-1	SA-351- CF3	P8-1	SA-182 F304L SA-312TP 304L	P8-1	
			SA-403 WP304L WP316L	P8-1	SA-182 F304L	P8-1	SA-403 WP304L	P8-1	
D_2o Upgrading Clean-up and Down graded D_2O Storage System (Partially)	SA -312 TP304L	P8-1	SA -182F304L	P8-1	SA351 CF3	P8-1	SA-182F 304L	P8-1	
			SA -403 WP-304L	P8-1	SA182 F304L	P8-1	SA-312 TP 304L SA-403 WP304L	P8-1 P8-1	
	SA -106 Gr.B	P1-1	SA -105 SA-234Gr. WPB	P1-2 P1-1	SA216 Gr.WCB SA-105	P1-1 P1-2	SA-106 Gr B	P1-1	
	BIS:1239	P1*	SA -181 Cl 70	P1-2			SA 181 Cl 70	P1-2	
Primary System including feeders and headers	SA-312 TP304L	P8-1	SA-403 WP-304L & SA-182 F304L	P8-1	SA-351CF3	P8-1	SA-333 Gr6	P1-1	
	Inconel SB-166 Alloy * 600	P43	SA-420 Gr. WPL6/ SA-350 Gr. LF2	P1-1 P1-2	SA-182 F316L SA-350, Gr.LF2	P8-1 P1-2	SA-312 TP 304L /316L SA-216 Gr.WCB	P8-1 P1-2	
	SA-333. Gr. 6	P1-1			SA-352 GrLCB	P1-1	SA-350 Gr. LF2	P1-2	
Reactor Auxiliary System(LWS)	SA 312 TP 304L	P8-1	SA-403 WP304L SA-182 F304L	P8-1 P8-1	SA-182 F304 SA 351 Gr.CF3M	P8-1 P8-1	SA-312 TP 304 SA-182 F 304L	P8-1 P8-1	
	SA-106 Gr.B	P1-1	SA-105	P1-2	SA-182 F 304L	P8-1			
	SA-53 Gr.B	P1-1	SA-234 Gr. WPB	P1-1			SA-53, Gr.B	P1-1	
	SA-672 Gr.60 Cl 12	P1-1	SA-515 Gr. 60	P1-1	SA105 SA-216 Gr.WCB SA-479 TP-410	P1-2 P1-2 P6-1	SA-672 Gr.60 Cl-12	P1-1	
Fuel Handling Process System	SA-312 TP304L	P8-1	SA-403 WP304L SA-182 304L	P8-1 P8-1	SA-182-F 304L SA-351 CF3	P8-1 P8-1	SA-312 TP304L	P8-1	Screwed & flange type connection used in the system

APPENDIX – E

GENERAL REVIEW OF MATERIAL SPECIFICATIONS OF NPP PIPING

System	Pipe		Fitting		Valves		Equipment Nozzle		Remarks
	Spec. & Grade	ASME P.No.& Gr.No.	Spec. & Grade	ASME P.No.& Gr. No.	Spec. & Grade	ASME P.No.& Gr. No	Spec. & Grade	ASME P.No. & Gr. No.	
Common Services(LWS) and Air systems inside Reactor Building	SA-312 TP304L SA-53 Gr.B SA-672 Gr.60 Cl-12& 13	P8-1 P1-1 P1-1	SA-182 F304L SA-105 SA-403 WP304L SA-234 Gr. WPB BIS:2002 Gr.2 SA:515 Gr.60	P8-1 P1-2 P8-1 P1-1 P1* P1-1	SA-105 SA-182 F304L SA351 CF3, CF3M SA-216 Gr.WCB SA-479 TP410	P1-2 P8-1 P8-1 P1-2 P6-1	SA-53 Gr.B SA-106 Gr.B BIS:2002 Gr. 2 SA-515 Gr.60 SA-182 F304L SA-312 TP304L SA-672 Gr.60 Cl 12/13	P1-1 P1 P1-* P1-1 P8-1 P8-1 P1-1	
Secondary System inside RB	SA 333 Gr.6	P1-1	SA-420 Gr.WPL-6/ SA-350 Gr.LF-2 Class-1 (Seamless)	P1-1 P1-2	**		**		
Secondary System outside RB	SA 335. Gr.P22 (Seamless)	P5A-1	SA-234 Gr.WP22 SA-182 Gr.F-22 Cl- I (Seamless)	P5A-1 P5A-1	**		**		
	SA-106, Gr.B (Seamless)	P1-1	SA-234 Gr. WPB SA-105 (Seamless)	P1-1 P1-2	**		**		
	SA-312 TP304L/ 316L (Seamless)	P8-1	SA-403 WP304L/ 316L SA-182 F304L F316L(Seamless)	P8-1 P8-1	**		**		
Common Service (Light water system) & Air systems outside reactor building	SA-53 Gr B. BIS:3589 Gr.410 BIS:2002Gr 2 SA-672Gr 60 Cl-12&13 (SA-515 Gr 60 plates) SA-312 TP304L SA-106 Gr.B	P1-1 P1-* P1-* P1-1 P8-1 P1-1	BIS-2002 Gr 2 SA-105 SA-234 Gr.WPB SA-403 WP-304L SA-182 F-304L SA-515 Gr 60	P1-* P1-2 P1-1 P8-1 P8-1 P1-1	SA-105 SA-182 Gr.F 304L SA-216 Gr.WCB SA-516 Gr.70 BIS:778 Cl Bronze BIS:210 Gr.260 SA-351 Gr CF 3	P1-2 P8-1 P1-2 P1-2 P1-* P1-* P8-1	BIS:2002 Gr 2 SA-53 Gr B. SA-672Gr 60 Cl-12&13 SA-106 Gr.B SA-515 Gr 60 SA-182 F-304L	P1-* P1-1 P1-1 P1-1 P1-1 P8-1	Valve and equipment nozzles with flanged/ socket welded ends are also provided in the system

APPENDIX – E

GENERAL REVIEW OF MATERIAL SPECIFICATIONS OF NPP PIPING

System	Pipe		Fitting		Valves		Equipment Nozzle		Remarks
	Spec. & Grade	ASME P.No.& Gr.No.	Spec. & Grade	ASME P.No.& Gr. No.	Spec. & Grade	ASME P.No.& Gr. No	Spec. & Grade	ASME P.No. & Gr. No.	
					SA-479 TP 410	P6-1	SA-403 WP-304L	P8-1	
Waste Management Plant ***	ASTM A 106 Gr.B	P1-1	ASTM A-105 (for Size 40NB & below)	P1-2	ASTM A-105 (For SW and screwed end valves)	P1-2	ASTM A-106 Gr.B & ASTM A-105 (For flanges/half coupling/ threaded coupling)	P1-1 P1-2	
			ASTM A-234 Gr.WPB (for Size 50NB & above)	P1-1	ASTM A-216 Gr. WCB (For BW and Flanged end valves)	P1-1			
			ASTM A-105 (For flanges of all sizes)	P1-1					
****	ASTM A 312 TP 304L	P8-1	ASTM A-182 F304L (for Size 40NB & below)	P8-1	ASTM A-182 F304L (For SW end valves)	P8-2	ASTM A-312 TP304L & ASTM A-182 F304L (For flanges/half coupling/ threaded coupling)	P8-1 P8-1	
			ASTM A-403 WP 304L (for Size 50NB & above)	P8-1	ASTM A-182 F304 (For screwed end valves)	P8-1			
			ASTM A-182 F304L (For flanges of all sizes)	P8-1	ASTM A-351 Gr. CF8 (For BW and flanged end valves)	P8-1			

* For materials where group No. is not mentioned the applicability of welding procedure/qualifications for different material specification shall be at the discretion of the Engineer.

** Material as per Vendor's drawings.

*** ANCW (other than resin transfer / fixation system) PAW, TTW, LW , Rain water , steam , SA, IA, MA, CHW, Domestic water ,Fire water, Treated waste and above ground drain lines of laundry system .

**** ACW, All process lines in resin transfer / fixation system except utility lines unless otherwise specified ,DM Water , all lines of Decontamination system except utility lines i.e. IA,CHW,SA & Steam . All equipment drain & floor drain collection points & further routing.

APPENDIX - F

SELECTION OF FILLER METALS

(For details of preheat and Post weld heat treatment (PWHT) specified in this Appendix, refer to Appendix G)

Materials to be welded	P. No.	Arc Welding Covered Electrodes		Welding Rods & Bare Electrodes		Consumable Insert ASME/AWS	Preheat	Post Weld heat Treatment (PWHT)
		ASME SFEC	AWS Classification (F no's)	ASME/ AWS SFEC.	AWS Classification (F no's)			
Carbon Steels	1	SFA5.1/AWS A5.01	E7018-1(F-4)	SFA5.18 /A5.18	ER70S-6 (F-6) ER70 S-2 F-6	SFA5.30 Group A INMs 3 SFA 5.30 Gr. INMs-1	Preheat as required in Appendix G	PWHT joints 12 mm thick and above on primary Heat Transport system including reactor Headers but excluding E.C.C.H20 recirculation sub-system. Argon purging required during heat treatment of above system. Also PWHTof joints above 19mm thick on all other systems. See details in Appendix G.
Austenitic Stainless Steel Type 304 only	8	SFA5.4	E308-16 (F-5)	A5.9	ER 308 (F-6)	SFA 5.30 Group C IN 308	NONE	NONE
Austenitic Stainless Steel Type 304L only	8	SFA5.4	E308L-16 (F-5)	A5.9	ER 308L (F-6)	SFA 5.30 Group C IN 308L	NONE	NONE
Austenitic Stainless Steel Type 347 only	8	SFA5.4	E347-16 (F-5)	A5.9	ER 347 (F-6)	SFA 5.30 Group C IN 348	NONE	NONE

APPENDIX – F – CONTD.....

SELECTION OF FILLER METALS

Materials to be welded	P. No.	Arc Welding Covered Electrodes		Welding Rods & Bare Electrodes		Consumable Insert ASME/AWS	Preheat	Post Weld heat Treatment (PWHT)
		ASME SFEC	AWS Classification (F no's)	ASME SFEC.	AWS Classification (F no's)			
Austenitic Stainless Steel Type 316 only	8	SFA5.4	E316-16 (F-5)	A5.9	ER 316 (F-6)	SFA 5.30 Group C IN 316	NONE	NONE
Austenitic Stainless Steel Type 316L only	8	SFA5.4	E316L-16 (F-5)	A5.9	ER 316L (F-6)	SFA 5.30 Group C IN 316L	NONE	NONE
Carbon Steel to Austenitic Stainless Steel	P1 to P8	SFA5.4	E309-16 (F-5)	SFA5.9	ER 309 (F-6)	SFA 5.30 Group C IN 310	NONE	NONE
Carbon Steel to Inconel	P1 to P43			SFA5.14	ER.Ni.Cr-3 (F-43) ER-Ni-Cr-Fe-6 F-43	SFA 5.30 Group E IN 82 SFA-5.30 Gr E IN 6A	NONE	NONE
Low Alloy Steel 2¼%Cr,1 %Mo	P5A toP5 A	SFA5.5	E9018-B3	SFA5.28	ER90S-B3		Preheat as required in Appendix G	Preheat as required in Appendix G
Low Alloy Steel 2¼%Cr,1 %Mo to CS	P5A toP1	SFA5.5	E9018-B3	SFA5.28	ER90S-B3		-do-	-do-
Low Alloy Steel 1¼%Cr,1 %Mo	P4to P4	SFA5.5	E8018-B2	SFA5.28	ER80S-B2		-do-	-do-

APPENDIX – F – CONTD.....

SELECTION OF FILLER METALS

Materials to be welded	P. No.	Arc Welding Covered Electrodes		Welding Rods & Bare Electrodes		Consumable Insert ASME/AWS	Preheat	Post Weld heat Treatment (PWHT)
		ASME SFEC	AWS Classification (F no's)	ASME SFEC.	AWS Classification (F no's)			
Low Alloy Steel 1¼%Cr,1%Mo to CS	P4to P1	SFA5.5	E8018-B2	SFA5.28	ER80S-B2		-do-	-do-
Low Alloy Steel 2¼%Cr,1%Mo to Low Alloy Steel 1¼%Cr,1%Mo	P5A toP4	SFA5.5	E9018-B3	SFA5.28	ER90S-B3		-do-	-do-
Brazing of copper alloys with less than 0.5% Aluminium	107			SFA5.8	BAg-1(F101) or BCu P-5 (F103) or 95-5 Tin Antimony or 50-50 Zinc-Pb		NONE	NONE

APPENDIX - G
Preheat and Post Weld Heat Treatment of Weld

1. This Appendix shall be read in conjunction with Para 16 and Appendix F of this specification.
2. Necessity of Heat Treatment shall be governed by weld size unless otherwise specified in drawings and other relevant NPC specifications.
3. The minimum holding time at post weld heat treatment temperature shall be:
   1) One hour for materials with a thickness up to 25 mm
   2) 25 minutes per cm of thickness for materials thicker than 25mm. However for P nos. 1 materials over 50 mm and up to 125 mm, minimum holding time shall be two hours plus 6 minutes for each additional cm over 50 mm.
   3) Preheat & PWHT requirements for Alloy Steels i.e.P3, P4&P5 shall be in accordance with ASME B31.1/Section III NC where ever applicable.
4. Thickness, mentioned in 3 (1) & (2) is thickness of weld, pressure retaining material or the thinner of the sections being joined, whichever is least. For fillet-welds, the thickness is the throat thickness, and for partial penetration and the material repair welds the nominal thickness is the depth of the weld groove or preparation.
5. During the holding period, the greatest difference between the highest and lowest temperature throughout the portion of the piping being heated shall not exceed 55 deg. C.
6. When non-pressure parts are welded to pressure parts, the post weld heat treatment temperatures of the pressure part shall govern.
7. When pressure parts of the different P number groups are joined by welding, the post weld heat treatment shall be in accordance with requirements of the material requiring the higher post weld heat treatment temperature range.
8. Where preheat is specified it shall apply to tack welds, attachment welds, thermal cutting and weld repairs. Preheating shall not be mandatory for tack welds of P1 materials where those are to be removed during root run.
9. Preheat temperatures shall be maintained during welding. No interruption of welding shall be permitted except to the extent required by specified stages of examination.
10. Above 427 deg. C the rate of heating and cooling in any hourly interval shall not exceed 220 deg. C divided by the maximum thickness in multiples of 25 mm of the material being heat treated, but shall not exceed 220 deg.C and need not be less than 55 deg. C in any hourly interval. Components with a temperature 425 deg. C or less may be cooled in still air. During heating and cooling period there shall not be a greater variation in temperature than 121 deg. C within any 4.5 M interval of weld length.

APPENDIX –G – CONTD.....

P GROUP	PREHEAT		POST WELD HEAT TREATMPOST WELD HEAT TREATMENT (PWHT)	
	TEMP DEG. C.		HOLDING TEMP. RANGE DEG. C	
P1	121	1. Preheat shall be applied whenever material has (i) maximum carbon content of 0.3% or less and thickness in excess of 30 mm OR (ii) maximum carbon content in excess 0.3% and thickness in excess of 20 mm. (This does not apply to fillet welds 12 mm and under in size that are used to attach insulation clips. 2. In no case shall the base material temperature be less than 10 deg. C 3. Preheat is required for Primary system and Headers System for thickness 12mm and above. This excludes E.C.C. H2O recirculation sub-system. Temperature of weld zone shall be maintained at or above 93 deg. C throughout the welding process 4. Preheat is required for steam system if thickness is greater than 19 mm and carbon is more than 0.25% - USI-36110. Temperature of weld zone shall be maintained at or above 93 deg. C throughout the welding process.	595-675	1. When it is impractical to heat treat at the temperature specified in this table, it is permissible to heat treat at lower temperatures as follows: At 565 deg. C the holding time shall be 50 mts/cm of thickness. At 540 deg. C the holding time shall be 70 mts/cm of thickness. When PWHT is done at decreased temperatures, the welding procedure qualification test specimens shall receive the same heat treatment. 2. The above heat treatment at lower temp. is not intended to cover cases where the minimum PWHT temperature was not achieved due to inadequate temperature control. 3. PWHT is not required for circumferential welds or socket welds in pipes or tubes that have a nominal wall thickness of 19 mm or less at the joint. However for wall thickness of 12 mm and above on primary Heat Transport, Headers Systems, excluding E.C.C. H2O recirculation sub-system, post weld heat treatment shall be done. In secondary system PWHT shall be carried out if pipe thickness is greater than1 9 mm. 4. PWHT is not required for fillet welds attaching non-pressure parts to pressure parts that have a throat thickness of 12 mm or less if preheat to a minimum temp. of 95 deg. C is applied when thickness of the pressure part exceeds 19 mm.

NOTE : 1) Requirements for exempting PWHT of nozzles to components weld & branch to run piping welds shall be as per NB/NC/ND-4622.7 (b)-1 as applicable.

2) Preheat and post weld heat treatment requirements for alloy steel P-3, P-4 and P-5 materials shall be in accordance with ASME B 31.1 clause no.131&132 respectively.

3) For P-5 material preheating and PWHT to be carried out for pipe size above 100 mm NB.

APPENDIX - H

TYPE OF WELDS	BUTT WELDS		NOZZLE WELDS		SEAL WELDS		SOCKET WELD/ SLIP ON FLANGES JOINTS		STRUCTURAL ATTACHMENT WELD		HANGER & SUPPORT WELD		BRAZE JOINTS
LEVEL	ROOT PASS	COMPLE-TED WELD	ROOT PASS	COMPLETED WELD	FIRST PASS	FINAL PASS	FIRST PASS	FINAL PASS	FIRST PASS	FINAL PASS	FIRST PASS	FINAL PASS	
LEVEL 1A	V+S	V+S+R	V+S	V+S+R*	V+S	V+S	V+S	V+S	V+S	V+S	V+S1	V+S	V+3% DES-TRUCTIVE TEST FOR ALL LEVELS
LEVEL 1B	V	V+S+R	V	V+S+R*	V	V+S	V	V+S	V	V+S	V	V+S	
LEVEL 2	V	V+R	V	V+S (upto 100 NB) V+R2 (>100NB)	V	V+S	V	V+S	V	V+S	V	V+S1	
LEVEL 3	V	V+S+R1	V	V+S (upto 100 NB) V+R2 (>100NB)	V	V+S	V	V+S	V	V+S	V	V+S1	
LEVEL 4	V	V+S	V	V+S1	V	V+S	V	V+S1	V	V	V	V	
LEVEL 5	V	V+S1	V	V+S1	V	V	V	V+S1	V	V	V	V	

NOTES : 1) V = 100% visual examination
R* = 100% radiographic examination for 100 mm NB and over pipe branch connection nozzle joints
R = 100% Radiographic examination, R1 = 5% Radiographic exam. & R2 = 5% Radiographic exam. for 100 mm NB and over pipe and nozzle joints.
S = 100% supplementary examination (i.e. Magnetic particle on ferritic material and liquid penetrant on others)
S1 = 10% supplementary examination
The external surfaces adjacent to weld joints for at least 12 mm on each side of weld edge shall be examined.

2) In case of inaccessible joints in pipes and fittings of less than 100 mm NB, the substitution of liquid penetrant examination for magnetic Particle examination on ferrous materials is left to the discretion of Quality Surveyor.
3) For 3% destructive testing of brazed joint and 10% supplementary examination (SI) of weld joint the penalty philosophy shall be same as per 10% radiography of the welded joints mentioned in clause 19.7 of this specification.
4) Closing joints if any made after system testing shall be examined as follows :
   i) Closing joints of the system having general examination level as Level-1A & B / Level-2 / Level-3 shall be examined as per the requirement of the Level-1 joint. ii) Closing joints of the system having general examination Level-4 / Level-5 shall be examined as per requirement of Level-3.
5) **Wherever joints require PSI, the joints shall be dressed-up and supplementary examination shall be carried out prior to radiography.**
6) **Any weld defect found during PSI shall be repaired. In case, radiography if specified, the re-radiography and re-UT testing records shall be maintained and will form base line data.**

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
	31280	Calandria OPRD Piping(Including interconnecting piping)	Safety Class 1 Seismic Category-1 Applicable Code- ASME-III NB	Whole Circuit.	Level 1A
		Moderator System	* Safety Class , Applicable Code for portion of pipe inside CV up to Ist isolation valve is taken as Class 1& ASME-III NB due to inaccessibility during service.		
	32000	Main Circulation	Safety Class 1* Seismic Category-1 Applicable Code- ASME-III NB*	Portion within the Calandria vault upto first isolating valve	Level 1A
			Safety Class 3 Seismic Category-1 Applicable Code- ASME-III ND	Rest of the circuit	Level 1B
	32210	Moderator Purification	Safety Class 3 Seismic Category-2 Applicable Code- ASME-III ND	Whole circuit	Level 1B
	32310	Moderator cover gas	Safety Class 3 Seismic Category-2 Applicable Code- ASME-III ND	Whole Circuit	Level 1B
		Moderator cover gas connection to Reactivity Devices	Safety Class 3 Seismic Category-2 Applicable Code- ASME-III ND	Whole Circuit	Level 1B
		Helium supply & venting system for VFU's & HFU's	Safety Class 3 Seismic Category-2 Applicable Code- ASME-III ND	Whole Circuit	Level 1B
	32400	Adjuster rod cooling	Safety Class 3 Seismic Category-2 Applicable Code- ASME-III ND	Whole Circuit	Level 1B
	32510	Leakage collection	Safety Class 3 Seismic Category-2 Applicable Code- ASME-III ND	Whole Circuit	Level 3

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
	32700	SDS#2	Safety Class 1 Seismic Category-1 Applicable Code- ASME-III NB Safety Class 3 Seismic Category-2 Applicable Code- ASME-III ND	Main Circuit. Auxiliary Circuit.	Level 1A Level 1B
	34520	Resin deutration	Safety Class 3 Seismic Category-3 Applicable Code- ASME-III ND	Whole circuit	Level 3
	34540	Resin dedeutraion	Safety Class 3 Seismic Category-3 Applicable Code- ASME-III ND	Whole circuit	Level 3
	34810	MLPAS	Safety Class 3 Seismic Category-1 Applicable Code- ASME-III ND	Whole circuit	Level 1B
	34910	F/M Vault leakage collection	Safety Class 3 Seismic Category 2 Applicable Code- ASME-III ND	Whole circuit	Level 3
	34920	D2OEvaporation and clean up	Safety Class 4 Seismic Category-2 Applicable Code- ASME Sec VIII Div-1	Whole circuit	Level 4
	34930	D2O Upgrading Plant	Safety Class 4 Seismic Category-2 Applicable Code- ASME Sec VIII Div-1	Whole circuit	Level 4
	34940	D_2O Sampling	Safety Class 3 Seismic Category-2 Applicable Code- ASME-III ND	Whole circuit	Level 3
	34960	D_2O addition and transfer	Safety Class 3 Seismic Category-2 Applicable Code- ASME-III ND	Whole circuit	Level 2
	34980	*Vacuum Mopping System*	*Safety Class-3* *Seismic Category-2* *Applicable Code- ASME- III-ND*	*Whole circuit*	*Level 3*

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
	34990	Downgraded D_2O Storage	Safety Class 4 Seismic Category-1 Applicable Code- ASME Sec VIII Div-1	Whole circuit	Level 4
	39000	LZC System	Safety Class 3 Seismic Category-2 Applicable Code- ASME-III ND	Whole circuit	Level 1B
		PHT SYSTEM			
	33110	Main circulation system and other systems upto 1st isolation valve	Safety Class 1 Seismic Category-1 Applicable Code- ASME-III NB	Whole circuit	Level 1A
	33116	Feeder system	Safety Class-1 Seismic Category-1 Applicable Code- ASME-III NB	Whole circuit	Level 1A
	33210	PHT purification System	Safety Class 2 Seismic Category-1 Applicable Code- ASME-III NC	Piping inside RB and from RB upto first isolation valve in RAB	Level 2
			Safety Class 3 Seismic Category-1 Applicable Code- ASME-III ND	Rest of the circuit	Level 3
	33230	D2OSampling	Safety Class-1 Seismic Category-1 Applicable Code- ASME-III NB	Upstream of Isolation Valve	Level 1A
			Safety Class-3 Seismic Category-2 Applicable Code- ASME-III ND	Down stream of isolation valve	Level 3
	33310	Feed System	Safety Class 2 Seismic Category-1 Applicable Code- ASME-III NC	Upstream of Isolation Valve	Level 1B

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
			Safety Class 1 Seismic Category-1 Applicable Code- ASME-III NB	Downstream of Isolation Valve	Level 1A
	33320	Bleed System	Safety Class 1 Seismic Category-1 Applicable Code- ASME-III NB	Whole circuit	Level 1A
	33330	Storage System	Safety Class 3 Seismic Category-1 Applicable Code- ASME-III ND	Up to Feed Pump	Level 3
		Inventory Addition &Recovery System	Safety Class-3 Seismic Category-1 Applicable Code- ASME-III ND	Whole Circuit	Level 3
	33340	Gland cooling System	Safety Class 2 Seismic Category-1 Applicable Code- ASME-III NC	Rest of Circuit	Level 1B
			Safety Class 1 Seismic Category-1 Applicable Code- ASME-III NB	Down stream of check valve on inlet line & upstream of MV on outlet line.	Level 1A
	33350	Emergency core cooling System	Safety Class 1 Seismic Category-1 Applicable Code- ASME-III NB	Down stream of check valve	Level 1A
			Safety Class 2 Seismic Category-1 Applicable Code- ASME-III NC	Accumulator circuit up to check valve	Level 1B
			Safety Class 3 Seismic Category-1 Applicable Code- ASME-III ND	Recirculation pump suction discharge, F/M vault and Service area drain lines	Level 3

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
	33360	Pressuriser Circuit	Safety Class 1 Seismic Category-1 Applicable Code- ASME-III NB	Whole circuit	Level 1A
	33370	F/M supply System	Safety Class 2 Seismic Category-1 Applicable Code- ASME-III NC	Circuit on discharge side up to F/M valve station & return valve	Level 1B
	33410	Shutdown cooling system	Safety Class-1 Seismic Category-1 Applicable Code- ASME-III NB	Whole circuit	Level 1A
	33510	Gas Addition System	Safety Class 2 Seismic Category-1 Applicable Code- ASME-III NC	H2 & N2 gas addition system (Whole circuit)	Level 2
			Safety Class 3 Seismic Category-1 Applicable Code- ASME-III ND	Rest of the circuit on suction side	Level 2
	33610	Relief circuit	Safety Class-1 Seismic Category-1 Applicable Code- ASME-III NB	Whole circuit	Level 1A
	33710	Leakage collection System	Safety Class-3 Seismic Category-1 Applicable Code- ASME-III ND	Whole circuit	Level 3
	33720	Service system	Safety Class 1 Seismic Category-1 Applicable Code- ASME-III NB	All lines connected to main circuit and bleed condenser up to first isolation valve	Level 1A
			Safety Class 2 Seismic Category-1 Applicable Code- ASME-III NC	All lines connected to shut down System	Level 1B
			Safety Class 3 Seismic Category-2 Applicable Code- ASME-III ND	Vacuum circuit and rest of the system	Level 3
	33820	*Resin Deuteration System*	Safety Class-4 Seismic Category-3 Applicable Code- ASME- III – ND	Whole circuit	Level 3

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
	33830	D2O Recovery System	Safety Class-3 Seismic Category-2 Applicable Code- ASME-III ND	Whole circuit	Level 3
	33840	*Resin De-deuteration System*	Safety Class-4 Seismic Category-3 Applicable Code- ASME- III-ND	Whole circuit	Level 3
	34330	*ECCS Sump Recirculation System*	*Safety Class-3* *Seismic Category- OBE* *Applicable Code- ASME- III-ND*	*Whole circuit*	*Level 3*
	36110	*Steam Lines on SG for LT, PT & FE, etc.*	*Safety Class-1* *Seismic Category-1* *Applicable Code- ASME- III-NB*	*From SG to root valve (inclusive)*	*Level 1A*
	36730	Passive Decay Heat Removal System	Safety Class-2 Seismic Category-1 Applicable Code- ASME- III-NC	Whole circuit	Level 1B
	36600	*SG steam & water sampling system (RB & RAB))*	Safety Class 2 Seismic Category-1 Applicable Code- ASME-III NC	Whole circuit	Level 1B
	36710	*Fire water injection to ECCS, SG & PDHRS*	Safety Class 2 Seismic Category-1 Applicable Code- ASME-III NC	Whole circuit	Level 1B
Fuel Handling System					
	35228	Fuelling Machine Heavy Water System	Safety Class 3 Seismic Category-1 Applicable Code- ND	1) Within F/M D2OValve Station 2) F/M Drain Line up to FM D2O Tank	Level 1B
	35227	Fuelling Machine Pneumatic Supply Lines	Safety Class 3 Seismic Category-1 Applicable Code- ASME-III ND	Within F/M D2OValve Station	Level 1B
	35218/ 35318	FT H2O System	Safety Class 2 Seismic Category-1 Applicable Code- ASME-III NC	All Lines of FT H2O System	Level 1B
	35217	FT Pneumatic System	Safety Class 3 Seismic Category-1 Applicable Code- ASME-III ND	All Lines of FT Pneumatic System	Level 1B
	35216	*FT Oil Hydraulic System*	*Safety NNS* *Seismic Category-3* *Applicable Code- ASME-B31.1*	*All pipe lines of the System*	*Level 4*

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
	35226	*FM Oil Hydraulic System*	*Safety NNS* *Seismic Category-3* *Applicable Code- ASME-B31.1*	*All pipe lines of the System*	*Level 4*
	35234	Rehearsal Facility	Safety Class 3 Seismic Category-1 Applicable Code- ASME-III ND	All Lines of RTF System	Level 1B
	62136	*FH Aux. Oil Hydraulic System*	*Safety NNS* *Seismic Category-3* *Applicable Code- ASME-B31.1*	*All pipe lines of the System*	*Level 4*
	Reactor Aux. System				
	34110	End Shield Cooling System	a) Safety Class-2 Seismic Category-1 Applicable Code - ASME-III (NC)	Piping within insulation cabinet.	Level 1B
			b) Safety Class-2 Seismic Category-1 Applicable Code - ASME-III (NC)	Piping in between containment isolation / anchors	Level 1B
			c) Safety Class – 3 Seismic Category 1 Applicable Code ASME-III (ND)	Rest Circuit	Level 3
	34160	Calandria vault cooling system	Safety Class-3 Seismic Category-1 Applicable Code - ASME-III ND	Complete circuit except for piping in between containment isolation / anchors	LEVEL 3
			Safety Class-2 Seismic Category-1 Applicable Code - ASME-III NC	Piping in between containment isolation / anchors &inside CV.	Level 1B
	34200	Containment Spray System	Safety Class-2 Seismic Category-1 Applicable Code - ASME-III (NC)	Whole Circuit	Level 1B
	34400	Spent fuel storage and receiving bay cooling system	Safety Class-3/Seismic Category-1/Applicable Code - ASME-III (ND)	a) Piping inside bay. b) Rest of the circuit.	LEVEL 2 LEVEL 3
	34320	Vapour suppression Pool Cooling System (Not Applicable for 700 MWe PHWRs)	Class 3 (ND)	Whole circuit	LEVEL 3

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
	34710	a) Annulus Gas System Inside RB	a)Safety Class –3 Seismic Category –I, Applicable Code: ASME SEC. III (ND).	Tubing,Piping,Valves and drain tank inside RB.	LEVEL 2
		b) Annulus Gas System Outside RB	b) Safety Class –4 Seismic Category –3 Applicable Code: ASME SEC. VIII Div-1	Piping Blowers Outside RB.	LEVEL 3
		c) RB penetration	c) Safety Class –2 Seismic Category –1 Applicable Code: ASME SEC. III NC	Containment Isolation Valve & Piping System	LEVEL 2
	Secondary System				
	36110	Main Steam System	a) Safety Class –2, Seismic Category –I, Applicable Code: ASME SEC. III (NC).	a) From Steam Generator (1 & 2), (3 & 4) upto first Anchor down strem of MSIV. Including Relief & discharge lines.	LEVEL 1B
			b) Safety Class–NINS, Seismic Category-3, Applicable Code: ANSI B31.1	b) Main Steam Line from first Anchor down strem of MSIV to H.P. turbine & to second stage reheater.	LEVEL 2
			c) Safety Class - NINS Seismic Category 3 Applicable Code ANSI B31.1	c) Connecting header between main steam lines & dump lines to condenser including dump valve.	LEVEL 2
			d) Safety Class- NINS, Seismic Category 3, Applicable Code ANSI B31.1	d) Main Steam (pegging steam) Line to Deaerator. Line to Gland Steam System	LEVEL 2
	36120	Main Steam & Discharge Relief	Safety Class –2, Seismic Category-I, Applicable Code: ASME SEC. III (NC)	Steam Discharge/Relief Lines.	LEVEL 1B

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
	36310	Boiler Blow Down System	a) Safety Class-2, Seismic Category – I, Applicable Code ASME III (NC)	a) Portion of the line from S.G. (Inside Reactor Bldg.) to first Anchor out side RB beyond containment isolation valve.	LEVEL 1B
	36310	Boiler Blow Down System	b) Safety Class –NINS, Seismic Category –3, Applicable Code -ANSI B31.1	b) Portion of the line from Anchor beyond containment isolation valve upto nozzle of Boiler Blow Down Tank	LEVEL 2 (Thk. >19 mm) LEVEL 3 (Thk. < or = 19 mm) (For Alloy Steel see special requirement below)*
	36410	Boiler Blow Down System	c) Safety Class-NINS, Seismic Category 3, Applicable Code-ANSI B31.1	c) Portion of the line from Boiler blow Down Tank nozzle to Blow Down Cooler	LEVEL 2 (Thk. >19 mm) LEVEL 3 (Thk. < or = 19 mm) (For Alloy Steel see special requirement below)*
			d) Safety Class-NINS, Seismic Category-3, Applicable Code-ANSI B31.1	d) Portion of the lines beyond Boiler Blow Down Cooler	LEVEL 4 (For Alloy Steel see special requirement below)*
	36510	SG water conditioning system (Chemical Feed System)	Safety Class-NINS, Seismic Category-3, Applicable Code-ANSI B31.1	a) Portion of the chemical feed piping down stream of last isolation valve before joining the feed point. b) Rest of the circuit	Level as per the system to which the chemical feed is connected. LEVEL- 5
	36810	Auxiliary Steam System	a) Safety Class-2, ,Seismic Category-I, Applicable Code ASME-III (NC)	a) Portion of the piping routed through or over the roof of safety related building	LEVEL 1B

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
			b) Safety Class –NINS, Seismic Category –3, Applicable Code -ANSI B31.1	b) Rest of circuit	LEVEL 2
	36820	Auxiliary Condensate System	Safety Class-NINS Seismic Category -3. Applicable Code-ANSI B31.1	Whole Circuit	LEVEL 5
	41120	Separator Drain System	Safety Class-NINS Seismic Category-3 Applicable Code ANSI B31.1	Whole Circuit	LEVEL 4 (For Alloy Steel see special requirement below)*
	41130	Reheater Drain System	a) Safety Class-NINS, Seismic Category – 3, Applicable code: ANSI B31.1	a) All circuits except bled steam reheater drain (stage-I) & vent lines as given in (b) below.	LEVEL 2 (Thk. >19 mm) LEVEL 3 (Thk. < or = 19 mm) (For Alloy Steel see special requirement below)*
			b) Safety Class-NINS, Seismic Category – 3, Applicable code ANSI B31.1	b) Vent Pipe Lines from live steam reheater drain tanks (LSRDT), bled steam reheater drain tanks (BSRDT) to moister separator reheater (MSR), vent from L.S.R.D/BSRD. tanks to deaerator, and bled steam reheater drain (stageI) circuit.	LEVEL 4 (For Alloy Steel see special requirement below)*
	41320	Turbine Oil Storage / Purification System	Safety Class-NINS Seismic Category –3.Applicable Code ANSI B31.1	Whole Circuit	LEVEL 5
	42120	Condenser Air Extraction System	Safety Class-NINS Seismic Category –3 Applicable Code ANSI B31.1	Whole Circuit	LEVEL 4
	43110	Bled Steam System	Safety Class-NINS, Seismic category-3, Applicable Code ANSI B31.1	Extraction 5, 6 , 7 and rest of the circuit/extractions.	LEVEL 4 (For Alloy Steel see special requirement below)*

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
	43130	H.P.& L.P Heater Drain System	Safety Class –NINS, Seismic Category-3, Applicable Code ANSI B31.1	Whole circuit	LEVEL 4 (For Alloy Steel see special requirement below)*
	43140	L.P.Heater Vent System	Safety Class –NINS, Scismic Category –3, Applicable Code ANSI B 31.1	Whole circuit	LEVEL 4 (For Alloy Steel see special requirement below)*
	43140	H.P.Heater Vent System	Safety Class –NINS, Seismic Category-3, Applicable Code ANSI B31.1	Whole circuit	LEVEL 4 (For Alloy Steel see special requirement below)*
	43210	Condensate/ Boiler Feed System/ABFP	a) Safety Class –NINS, Seismic Category-3, Applicable Code ANSI B 31.1	a) Condensate System & Suction of Boiler Feed pumps	LEVEL 4 (For Alloy Steel see special requirement below)*
			b) Safety Class –NINS, Seismic Category-3, Applicable Code ANSI B 31.1 c) Safety Class –NINS, Seismic Category-3, Applicable Code ANSI B 31.1	b) Boiler feed pump discharge piping up to first anchor out side reactor bldg. on PC bay & complete recirculation system. c) A.B.F.P. suction piping from deaerator upto first anchor on the suction line from deaerator and recirculation line to deaerator beyond pipe anchor on PC bay.	LEVEL 2 (For Alloy Steel see special requirement below)* LEVEL 2 (For Alloy Steel see special requirement below)*

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
			d) Safety Class –2, Seismic Category –I, Applicable code -ASME - III (NC)	d i) Aux. B.F.P. Suction piping from Aux. condensate storage tank (ACST) including portion of suction piping from deaerator beyond first anchor from deaerator and complete discharge piping including recirculation line to ACST. d ii) Recirculation line to deaerator up to pipe anchor on PC bay. d iii) Boiler feed water piping from first anchor on PC bay (near Turbine Building end) to steam generator . d iv)Aux. condensate tank drain line from ACST to pipe anchor on PC bay and initial fill and make-up line from pipe anchor on PC bay to ACST.	LEVEL 1B
	43310	Make Up & Reject System	Safety Class –NINS, Seismic Category –3, Applicable Code ANSI B 31.1	Whole Circuit	LEVEL 5 (For Alloy Steel see special requirement below)*
	45210	Steam Drain System	a)Safety Class –NINS, Seismic Category –3 Applicable Code ANSI B31.1	a) Drain (upto isolation valve) from main steam lines	LEVEL – As per Respective originating line. (For Alloy Steel see special requirement below)*
			b)Safety Class –NINS, Seismic Category –3, Applicable Code ANSI B31.1	b) Down stream of isolation valve	LEVEL 3 (For Alloy Steel see special requirement below)*
			c) Safety Class –NINS, Seismic Category –3, Applicable Code ANSI B 31.1	c) Drain from Extraction 7, 6, upto Isolation Valve	LEVEL 4 (For Alloy Steel see special requirement below)*

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
			d) Safety Class –NINS, Seismic Category –3, Applicable Code ANSI B 31.1	d) Remaining circuit All vent and drain to atmosphere after isolation valve shall be of Level 5	LEVEL 5 (For Alloy Steel see special requirement below)*
			e) Safety Class –NINS, Seismic Category –3, Applicable Code ANSI B 31.1 f) Safety Class –NINS, Seismic Category –3, Applicable Code ANSI B 31.1 g) Safety Class –NINS, Seismic Category –3, Applicable Code ANSI B 31.1	e) Flash tank drain & vent lines and any other lines which are connected to condenser and under vacuum normally. f) Other lines (drain/ vents) which are under vacuum normally. g) Turbine integral drains up to isolation valve	LEVEL 3 (For Alloy Steel see special requirement below)* LEVEL 3 (For Alloy Steel see special requirement below)* LEVEL 3(For drains from HP Turbine) LEVEL 4 (For drains from LP Turbines)
	45110	Sampling lines	Safety Class –2/NINS, Seismic Category –3, Applicable Code –ASME-Sec III-NC/ANSI B 31.1	Whole Circuit	LEVEL As per Respective originating line
*		Low Alloy Steel piping	All Safety Class (including NINS)	All system	LEVEL 1B In secondary system wherever part of the system alloy steel is used, inspection requirement shall be governed by Level 1B.
	Note	NINS - Non Important to Nuclear Safety Class			
	COMMON SERVICES				
	53530	Fuel Oil Storage Transfer System	Safety Class-3,Seismic Category -1,Code ASME III ND	Whole Circuit.	LEVEL 3
	71120	Plant Water System	Safety Class-NINS,Seismic Category -3,Code ANSI B31.1	Whole Circuit	LEVEL 5

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
	71210	Condenser Cooling Water supply System	Safety Class-NINS,Seismic Category -3,Code ANSI B31.1	Whole Circuit	LEVEL 5
	71230	Blowdown from C.W. System	Safety Class-NINS,Seismic Category -3,Code ANSI B31.1	Whole Circuit	LEVEL 5
	71240	Condenser water Box Vacuum Priming System	Safety Class –NINS, Seismic Category -3 ,Applicable Code ANSI B31.1	Whole Circuit	LEVEL 5
	71310 (&/ or 71330)	Active Process Water System (Single Pressure / Two Pressure System)	a) Safety Class-3 Seismic Category-1 Applicable Code - ASME-III (ND) b) Safety Class-2 Seismic Category-1 Applicable Code - ASME-III (NC)	Complete circuit except for piping in between containment isolation / anchors Piping in between containment isolation / anchors	Level 3 Level 1B
	71350	Auxiliary Cooling Water System (Non-Safety Related Non Active Process Water System)	Safety Class –NINS Seismic Category – 3 Applicable Code – ANSI B 31.1	Whole Circuit	Level 5
	71400	Fire Water System	a)Safety Class-3 Seismic Category-1 Applicable Code - ASME-III (ND)	Fire water supply to safety related areas except for piping in between containment isolation / anchors	Level 3
			b) Safety Class-2 Seismic Category-1 Applicable Code - ASME-III (NC)	Piping in between containment isolation / anchors	Level 1B
			c) Safety Class –NINS Seismic Category 3 Applicable Code ANSI B 31.1	Rest Circuit	Level 5
	71500	Domestic Water System	Safety Class –NINS Seismic Category – 3 Applicable Code – ANSI B 31.1	Whole Circuit	Level 5
	71600	Demineralised Water System	a) Safety Class –NINS Seismic Category – 3 Applicable Code – ANSI B 31.1	Complete circuit except for piping in between containment isolation / anchors	Level 5
			b) Safety Class-2 Seismic Category-1 Applicable Code - ASME-III (NC)	Piping in between containment isolation / anchors	Level 1B

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Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
	71710	Nonactive Drainage System	Safety Class-NINS Seismic Category -3 Applicable Code ANSI B 31.1	Whole Circuit	Level 5
	71720	Active Drainage	a) Safety Class – 4 Seismic Category – 3 Applicable Code – ANSI B 31.1	Complete circuit except for piping in between containment isolation / anchors	Level 3
			b) Safety Class-2 Seismic Category-1 Applicable Code - ASME-III (NC)	Piping in between containment isolation / anchors	Level 1B
	71810	Service Water System	Safety Class-3 Seismic Category -I Applicable Code ASME III(ND)	a) Whole Circuit including blow down piping up to first seismic isolation valve	Level 3
			Safety Class-NINS Seismic Category -3Applicable code ANSI B 31.1	b) Blow down piping beyond seismic isolation valve referred in (a) above & up to discharge point.	Level 5
	71850	Auxilary Service Water System	Safety Class-NINS Seismic Category -3Applicable code ANSI B 31.1	Whole Circuit	Level 5
	71900	Chilled Water	a) Safety Class –NINS Seismic Category – 3 Applicable Code – ANSI B 31.1	Complete circuit except for piping in between containment isolation / anchors	Level 5
			b) Safety Class-2 Seismic Category-1 Appli. Code- ASME-III (NC)	Piping in between containment isolation / anchors	Level 1B
	75100	a) Class III Compressed Air System	Safety Class-3 Seismic Category -1 Applicable Code ASME III(ND)	Compressor Piping from compressors to Air Receivers, Air Receivers, Piping between Air Receivers to Air dryers.	Level 3
		b) Class IV Compressed Air System	Safety Class-NINS Seismic Category -3 Applicable Code ANSI B31.1	Compressor Piping from compressors to Air Receivers, Air Receivers ,Piping between Air Receivers to Air dryers .	Level 4
	75110	Class IV Service Air System	a) Safety Class-NINS Seismic Category -3 Applicable Code ANSI B31.1	Complete RB circuit except piping in between containment isolation valve / anchors	Level 4

APPENDIX – H – CONTD...

Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
			b) Safety Class-2 Seismic Category -1 Applicable Code-ASME SEC III NC	Piping in between containment isolation valve / anchors	Level 2
			c) Safety Class-NINS Seismic Category -2 Applicable Code ANSI B31.1	Whole circuit outside RB (for seismically qualified building)	Level 5
			d) Safety Class-NINS Seismic Category -3 Applicable Code ANSI B31.1	Whole circuit outside RB (for seismically not qualified building)	Level 5
	75120	Class III Instrument Air System	a)Safety Class-3, Seismic Category -1 Applicable Code ASME-III(ND)	Whole circuit except piping in between contain isolation valves/ anchors.	Level 3
			b) Safety Class-2 Seismic Category -1 Applicable Code-ASME SEC III NC	Piping in between contain isolation valves/ anchors..	Level 2
		Class IV Instrument Air System	a) Safety Class-NINS Seismic Category -2 Applicable Code ANSI B31.1	Complete RB circuit except piping in between containment isolation valves/anchors.	Level 3
			b) Safety Class-2 Seismic Category -1 Applicable Code ASME-III(NC)	Piping in between containment isolation valves/anchors.	Level 2
			c) Safety Class-NINS Seismic Category -2 Applicable Code ANSI B31.1	Whole circuit outside RB (for seismically qualified building)	Level 4
			d) Safety Class-NINS Seismic Category -3 Applicable Code ANSI B31.	Whole circuit outside RB (for seismically not qualified building)	Level 4
	73120	a)D2O Condensate collection system	a) Safety Class-2 Seismic Category -1 Applicable Code ASME SECIII NC	Containment penetration piping terminal points (As marked on PIS)inside ICW upto last isolation valves/anchors (outside OCW)	Level 2
			b) Safety Class-3 Seismic Category -1 Applicable Code ASME SECIII ND	Complete outside RB circuit except piping in between containment isolation valves/anchors (outside OCW)	Level 3

APPENDIX – H – CONTD...

Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
	75130	Class III Mask Air	a) Safety Class-4 Seismic Category -1 Applicable Code ANSI B31.1	Complete RB circuit except piping in between containment isolation valves/anchors.	Level 3
			b) Safety Class-2 Seismic Category -1 Applicable Code ASME SEC III NC.	Piping in between containment isolation valves/anchors.	Level 2
			c) Safety Class-4 Seismic Category -1 Applicable Code ANSI B31.1	Whole circuit outside RB.	Level 4
		Class IV Mask Air	a) Safety Class-NINS Seismic Category -2 Applicable Code ANSI B31.1	Complete RB circuit except piping in between containment isolation valves/anchors.	Level 4
			b) Safety Class-2 Seismic Category -1 Applicable Code ASME SEC III NC.	Piping in between containment isolation valves/anchors.	Level 2
			c) Safety Class-NINS Seismic Category -2 Applicable Code ANSI B31.1	Whole circuit outside RB (for seismically qualified building)	Level 5
			d) Safety Class-NINS Seismic Category –3 Applicable Code ANSI B31.1	Whole circuit outside RB (for seismically not qualified building)	Level 5
		WASTE MANAGEMENT SYSTEM			
	79210	WMP-LESS(PAW,ANCW,ACW,Drain& Samp-ling Lines)	Safety Class-4 Seismic Category -3 Applicable Code ANSI B31.1	Whole circuit	Level 3
		Utilities/Services like SA, MA, IA, FW&DW for LESS.	Safety Class-4 Seismic Category -3 Applicable Code ANSI B31.1	Whole circuit	Level 3
	79220	WMP-Storage Treatment,Evoparation,Decontamination,Active Drainage System & TTW lines.	Safety Class-4 Seismic Category -3 Applicable Code ANSI B31.1	Whole circuit	Level 3
		Liquid waste discharge lines-Out door & Underground lines.	Safety Class-4 Seismic Category -3 Applicable Code ANSI B31.1	Whole circuit	Level 3(Applicable to under ground Secondary pipe lines also)

APPENDIX – H – CONTD...

Sr No.	USI	SUB SYSTEM	SAFETY CLASS/ SEISMIC CATEGORY/ APPLICABLE CODE	PORTION OF CIRCUIT TO THE CLASS	LEVEL OF EXAMINATION
		Resin transfer and fixation systems	Safety Class-4 Seismic Category -3 Applicable Code ANSI B31.1	Whole circuit	Level 3
		Utilities / services like SA, MA, IA, FW, DW, DMW&CHW for WMP	Safety Class-4 Seismic Category -3 Applicable Code ANSI B31.1	Whole circuit	Level 3
		Steam & condensate lines.	Safety Class-4 Seismic Category -3 Applicable Code ANSI B31.1	Whole circuit with in WMP building(Condensate lines in WMP building and also up to UGP building)	Level 3

PAW = Potentially active waste, ANCW = Active non-chemical waste, ACW = Active chemical waste, SA = Service air, MA = Mask air, IA = Instrument air, FW = Fire Water, DW = Domestic water, WMP = Waste management plant, LESS = Liquid effluent segregation system , TTW=Tritiated waste,CHW=Chilled water ,DMW=Demineralised water

APPENDIX - I

All welding material in addition to material specification shall conform to ASME Section III NB 2400 for PHT, moderator and secondary shut down system and ASME Section III, NC 2400 for main steam System. Procurement of electrodes for all other systems shall be done as per material specification along with Lot classification as per class C-3 for covered electrods and S-2 for bare electrodes and consumable inserts and intensity of testing as per Schedule 'J' of SFA 5.01.

GUIDE TO WELDING PROCEDURE

Procedure No.	Base Material and Group	Welding Process	Welding rods electrodes & filler metals AWS Spec.	Application
1.	C.S. (P1)	SMAW	Low Hydrogen electrodes E7018-*1*	a) Secondary system outside reactor building. (except 36110, 43210, 41130) b) Reactor auxiliary system located outside F/M vault c) Common services inside and outside reactor building. d) Hangers and supports. f) Moderator system (C.S. lines to process water connection). f) Socket welds for all systems.
2.	CS (P1)	SMAW with preheat and post heat.	Low Hydrogen electrodes E7018-*1*.	All large size weldolets, welding on main steam lines USI 36110.
3.	S.S. (P8)	GTAW for root pass with consumable insert, GTAW stabilizing pass, remainder either SMAW or GTAW welding	Filler wire ER 308/ER308L and Electrodes E308-16/E308L-16 Consumable insert-SFA - 530 Group C, IN 308/IN 308 L	a) Moderator system b) Primary system c) Fuel transfer system d) Reactor auxiliary system. (inside F/M vault) e) Liquid poison injection. f) F/M D_2O Valve station. g) Secondary shut down
4.	S.S. (P8)	GTAW with addition of filler wire for root pass and stabilizing pass remainder either GTAW of SMAW	Filler wire ER308/ER308L and Electrode E308-16 or E308L-16	a) Same as procedure 3 above for branch welds. b) Common services (inside and outside (RB) c) RAS (outside F/M vault)
5.	C.S. (P1)	a) GTAW with addition of filler wire for root pass & stabilizing pass, remainder SMAW or GTAW	a)Filler wire to ER70S-6 and, E7018-*1*electrodes	a.i) Secondary system, USI 36120, 41130 & 43210, (Both inside and outside Reactor Building below 12 mm thickness) a.ii) Reactor auxiliary systems located in FM vaults.

APPENDIX – I – CONTD...

Procedure No.	Base Material and Group	Welding Process	Welding rods electrodes and filler metals AWS Spec.	Application
		.b) GTAW root pass with consumable insert, GTAW stabilizing pass, remainder SMAW or GTAW	b)Consumable inserts Group A-INMS-1 and filler wire ER70-S-2 and Electrode E7018-*1*	b) Primary system including Reactor Headers (below 12mm thickness)
6.	C.S.(P1)	GTAW with addition of filler wire, for root pass and stabilizing pass remainder SMAW or GTAW, Preheat &PWHT required for secondary systems	filler wire to ER-70S-6 or ER-70-S-2 & E7018-*1* electrodes	Secondary system .
7.	C.S.(P1)	GTAW root pass with consumable insert, GTAW stabilizing pass remainders either SMAW or GTAW	Consumable insert Gr A-INMS-1 and filler wire to ER-70S-2 and E7018-*1* electrodes	a) Feeders.(This procedure is specifically for feeder and must be qualified on small dia. pipes)
8.	C.S. to Inconel (P1 to P43)	GTAW welding root pass with consumable insert, remainder GTAW	Consumable insert SFA5.30, GrE, IN82 and filler wire to ER Ni-Cr3	a) Inconel orifice to feeder pipes/fittings of feeder system
9.	C..S. (P1)	GTAW for root pass with consumable insert, GTAW stabilizing pass remainder SMAW, Preheat and post weld heat required during post weld heat treatment of Primary system and reactor header.	Consumable insert SFA5.30 GrA, INMS-1/ INMS-3 and filler wire to ER-70S-2/and E7018-*1* electrodes	Primary system including Reactor Headers (12mm or above thickness)
10.	C.S. (P1)	GTAW for addition of filler wire for root and stabilizing pass, remainder SMAW Preheat and postheat required.	ER-70 S-2 filler wire and E7018-*1*electrodes	a) Same as procedure 9 for branch welds b) Secondary system, (outside RB 12 mm & above)

APPENDIX – I – CONTD...

Procedure No.	Base Material and Group	Welding Process	Welding rods electrodes and filler metals AWS Spec.	Application
11.	C.S. to S.S (P1 to P8)	GTAW for root pass with consumable insert GTAW stabilising pass, remainder either SMAW or GTAW.	Consumable insert GR. C IN 310 and filler wire to ER309 & Electrode to E309-16	a) Primary system b) Reactor Auxiliary System (inside F/M vault)
12.	Copper (P107)	Brazing process using Oxy-acetylene gas	Filler wire BAg-1 or BCu P-5 or 95-5 Tin Antimony	a) Common services (Inside Reactor Building) b) Reactor Auxiliary system
13.	C.S. to S.S (P1 to P8)	GTAW plus filler for root and subsequent passes	Filler wire ER-309/310	a) DN Monitoring Connection with feeders b) Can also be used for any application as per Procedure –II c) EP plates/structure member to SS pipes or vice-versa.
14.	C.S. (P1)	GTAW for root pass with or without consumable insert but without inert gas backing, GTAW stabilizing pass remainder with SMAW or GTAW	Consumable insert, Gr. A IN MS-3 filler wire ER 70 S-6 and electrodes E7018 or Consumable inserts Gr.A IN MS-1 Filler wire ER 70-S-2 & electrode E7018-*1*	Same as procedure 5 when purging is not possible (Exceptional cases of closing joints. Prior approval of Engineer is required for each joint)
15.	S.S. (P8)	SMAW	E308-16/E308L-16	Socket welds for all systems
16.	Low Alloy steel 2 ¼ % Cr, 1% Mo P5A to P5A	GTAW for root pass GTAW stabilizing pass, remindcr with GTAW/SMAW	ER 90 S – B 3 (SFA 5.28) E 9018 – B 3 (SFA 5.5)	Secondary cycle piping
17.	Low Alloy steel 2 ¼ % Cr, 1% Mo P5A to P 1	GTAW for root pass GTAW stabilizing pass, reminder with GTAW/SMAW	ER 90 S – B 3 (SFA 5.28) E 9018 – B 3 SFA5.5)	Secondary cycle piping
18.	Low Alloy steel 1 ¼ % Cr, ½ % Mo P4 to P4	GTAW for root pass GTAW stabilizing pass, reminder with GTAW/SMAW	ER 80 S – B 2 (SFA 5.28) E 8018 – B 2 (SFA 5.5)	Secondary cycle piping
19	Low Alloy steel 1 ¼ % Cr, ½ % Mo P4 to P 1	GTAW for root pass GTAW stabilizing pass, reminder with GTAW/SMAW	ER 80 S – B 2 (SFA 5.28) E 8018 – B 2 (SFA 5.5)	Secondary cycle piping

Notes:- 1) Pre-heat and Post Weld Heat treatment is required as per ASME B31.1 or ASME Section-111 NC as applicable

APPENDIX - J

ULTRASONIC INSPECTION OF WELDS

1.0 Ultrasonic Examination of pressure welds is required in addition to Radiographic Examination to obtain base line data for subsequent Periodic Examination of the erected systems.

2.0 Well dressing for Examination

All the pressure bearing welds in piping identified between two terminals for PSI (Preservice Service Inspection) shall be dressed up adequately for Ultrasonic Examination. Actual welds to be dressed up shall be identified by the NPCIL Quality Surveyor.

The weld dress up shall be adequate to ultrasonically examine the weld material and adjoining base material at least up to one base material thickness or 25 mm whichever is greater.

3.0 Extent of Ultrasonic Weld Examination and acceptance Standard

All the dressed up welds as mentioned in para 2 above shall be ultrasonically examined by the Contractor.

Ultrasonic examination of welds shall be performed in accordance with NPCIL specification no. PP-P-2009, (Procedure for Ultrasonic Examination of Pressure Retaining Welds of Steel Piping and Vessel Butt-weld Joints'-which is in accordance with the ASME Section XI) to ensure consistent detection and discrimination of transverse and longitudinal defects. The reference standards shall be made from material of the same composition, diameters, thickness and surface condition as the material heat treatment condition which is to be examined. The width, shape and method of producing the notches may be altered subject to NPCIL Quality Surveyor approval. The reference standard shall be supplied to the station for use by QA for ISI.

All ultrasonic defect indication shall be investigated to determine the defect size. Indicated defects which exceed the limits specified in NB-5330 of Section III of ASME Code are unacceptable, and shall be marked for rejection or repair in accordance with Section 12 of this Specification. Re-examination after repair shall be performed for the collection of baseline data.

NUCLEAR POWER CORPORATION OF INDIA LIMITED

QUALITY ASSURANCE PLAN FOR 6.6kV MOTORS

Scope and Purpose:

This document indicates the requirements expected from the package contractor/manufacturer of motors. Subsequent to the placement of Purchase Order, contractor/manufacturer shall submit for purchaser's approval a quality assurance plan in line with this document incorporating specific document numbers for "format of records", "acceptance norms" and "reference documents" etc. If required by the purchaser, reference documents indicated shall be shown before approval of QAP.

QAP NO: PC-E-503/Annex-C.
DATE:September, 2009

R: Review
P: Perform
W: Witness

H: Hold
1: NPCIL
2: Pakage Contractor

3: Motor Manufacturer/ External laboratory/manufacturer's Sub-contractor.

LEGEND

AD: NPCIL Approved Document such as Tender Document, Purchase order, Drawings & Test Procedures

Manufacturer reference documents to be detailed here

TR: Test Report
PS : Plant Standards
CHP: Customer's Hold Point (Customer is NPCIL)
IS: Indian Standards
IEC : International Electrotechnical Commission standards
IEEE: Institute of Electronics and Electrical Engineers standards

NOTES:

* Wherever V & W are both indicated , NPCIL QS to witness test or review TRs at NPCIL's choice.

*** TRs not more than five year old from date of purchase order may be reviewed for acceptance. Otherwise, test shall be carried out at no extra cost to NPCIL and within the committed delivery schedule.**

* Minor: The characteristic of a component, process or operation whose failure neither materially reduce the usability of the product in operation, nor does it affect the aesthetic aspects.

* Major: The characteristic of a component, process or operation whose failure may cause operation failure which cannot be readily corrected at site or cause substandard performance, increased erection and maintenance cost, reduced life or seriously affect aesthetics or ergonomics.

* Critical: The characteristics of a component, process or operation failure of which will surely cause operating failure or intermittent troubles which is difficult to rectify at site or render the unit unfit for use or safety hazards.

* ''Failure '' of a characteristic means failure to meet the 'acceptance norms '.
* Sampling: Generally in accordance with IS:2500. If 100% "witness" is carried out by "Package contractor", NPCIL will witness on sample basis, or if 100% "witness" is carried out by "Motor Manufacturer", "Package contractor" will witness on sample basis.

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY				REMARKS
									R	P	W	H	
1	**BOUGHT OUT ITEMS**												
1.1	Enamelled, Fibreglass covered, varnished rectangular copper conductor Class F for temp. class 155 deg. C	a) Overall Dimensions	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			TC to be furnished batchwise
		b) Bare conductor dimension	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			
		c) Increase in dimension due to insulation coverage	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			
		d) Chemical composition	Major	Chemical	1sample / lot	PS	PS	PS	1, 2	3			
		e) Flexibility	Major	Mechanical	1sample / lot	PS	PS	PS	1, 2	3			
		f) Cure test	Major	Physical	1sample / lot	PS	PS	PS	1, 2	3			
		g) Electrical strength proof voltage test	Major	Electrical	1sample / lot	PS	PS	PS	1, 2	3			
		h) BDV Test at 155 deg. C.	Major	Electrical	1sample / lot	PS	PS	PS	1, 2	3			
		I) Resistivity	Major	Electrical	1sample / lot	PS	PS	PS	1, 2	3			
1.2	Electrolytic tough pitch high conductivity copper (for rotor bars)	a) Tensille Strength	Major	Mechanical	1sample / lot	PS	PS	PS	1, 2	3			TC to be furnished batchwise.
		b) Elongation	Major	Mechanical	1sample / lot	PS	PS	PS	1, 2	3			
		c) Hardness	Major	Mechanical	1sample / lot	PS	PS	PS	1, 2	3			

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY				REMARKS
									R	P	W	H	
		d) Chemical Comp.	Major	Chemical	1sample / lot	PS	PS	PS	1, 2	3			
		e) Resistivity	Major	Electrical	1sample / lot	PS	PS	PS	1, 2	3			
		f) Free from surface defects	Major	Visual	1sample / lot	PS	PS	PS	1, 2	3			
		g) Dimensions	Major	Mechanical	3 sample / lot	Manufacturing Drgs.	Manufacturing Drgs.	PS	1, 2	3			
		h) DP test	Major	NDT	3sample / lot	PS	PS	PS	1, 2	3			
1.3	Short circuting ring.	a) Chemical comp.	Major	Chemical	1sample / lot	PS	PS	PS	1, 2	3			TC to be furnished batchwise.
		b) Tensile strength	Major	Mechanical	1sample / lot	PS	PS	PS	1, 2	3			
		c) Elongation	Major	Mechanical	1sample / lot	PS	PS	PS	1, 2	3			
		d) Conductivity	Major	Electrical	1sample / lot	PS	PS	PS	1, 2	3			
		e) UT	Major	Mechanical	100%	PS	PS	PS	1, 2	3			
		f) Dimensions	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1, 2	3			
		f) Visual inspection of cracks and blow holes	Major	Visual	100%			PS	1, 2	3			
		g) DP test after machining	Major	NDT	100%	PS	PS	PS	1, 2	3			
1.4	Insulating Material/Tapes	a) Dimensions	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			TC to be furnished batchwise.

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY				REMARKS
									R	P	W	H	
		b) Chem. comp.	Major	Chemical	1sample / lot	PS	PS	PS	1, 2	3			
		c) Compliance to specified temperature class.	Major	Review of test certificate	100%	PS	PS	PS	1,2	3			
		d) BDV	Major	Electrical	1sample / lot	PS	PS	PS	1, 2	3			
1.5	Insulating Varnish / Resins/ hardeners	a) Packing viscosity	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			TC to be furnished batchwise.
		b) Non volatile content	Major	Chemical	1sample / lot	PS	PS	PS	1, 2	3			
		c) Drying in thin layer	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			
		d) Curing in thick layer	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			
		e) Stability of varnish in open vessel	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			
		f) Effect of varnish on enamelled Glass covered wire	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			
		g) Electric strength at 155 deg. C.	Major	Electrical	1sample / lot	PS	PS	PS	1, 2	3			
		h) Electric strength at RT	Major	Electrical	1sample / lot	PS	PS	PS	1, 2	3			
		I) Volume resistivity	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			
1.6	Shaft material	a) Chemical comp.	Major	Chemical	1sample / lot	IS 2004 Class 2A	IS 2004 Class 2A	PS	1, 2	3			TC to be furnished batchwise.

QUALITY ASSURANCE PLAN
6.6kV INDUCTION MOTORS

SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY				REMARKS
									R	P	W	H	
		b) Hardness	Major	Mechanical	1sample / lot	IS 2004 Class 2A	IS 2004 Class 2A	PS	1, 2	3			
		c) Yield strength	Major	Mechanical	1sample / lot	IS 2004 Class 2A	IS 2004 Class 2A	PS	1, 2	3			
		d) Tensile strength	Major	Mechanical	1sample / lot	IS 2004 Class 2A	IS 2004 Class 2A	PS	1, 2	3			
		e) Elongation	Major	Mechanical	1sample / lot	IS 2004 Class 2A	IS 2004 Class 2A	PS	1, 2	3			
		f) Grain size	Major	Measurement	1sample / lot	IS 2004 Class 2A	IS 2004 Class 2A	PS	1, 2	3			
		g) Ultrasonic test	Critical	NDT	100%	PP-E-1213	PP-E-1213	PS		3	2	1	
1.7	Stamping Steel material	a) Specific total loss before and after ageing	Critical	Electrical	1sample / lot	PS	PS	PS	1,2	3			TC to be furnished batchwise.
		b) Magnetisation	Major	Electrical	1sample / lot	PS	PS	PS	1, 2	3			
		c) Insulation resistance	Major	Electrical	1sample / lot	PS	PS	PS	1, 2	3			
		d) Stacking factor	Major	Mechanical	1sample / lot	PS	PS	PS	1, 2	3			
		e) Ductility	Major	Mechanical	1sample / lot	PS	PS	PS	1, 2	3			
		f) Thickness	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			
		g) Thickness of coating	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY				REMARKS
									R	P	W	H	
1.8	Steel plates (For stator frames and end shields)	a) Thickness	Major	Measurement	1sample / lot	IS 2062 Class B	IS 2062 Class B	PS	1.2	3			
		b) Chemical comp.	Major	Chemical	1sample / lot	IS 2062 Class B	IS 2062 Class B	PS	1.2	3			
		c) Tensile strength	Major	Mechanical	1sample / lot	IS 2062 Class B	IS 2062 Class B	PS	1.2	3			
		d) Yield strength	Major	Mechanical	1sample / lot	IS 2062 Class B	IS 2062 Class B	PS	1.2	3			
		e) Elongation	Major	Mechanical	1sample / lot	IS 2062 Class B	IS 2062 Class B	PS	1.2	3			
		f) Ultrasonic test	Critical	NDT	1sample / lot	PS	PS	PS	1	3	2		UT>25 mm
1.9	Fans (fabricated)	a) Dimensions	Major	Measurement	100%	PS	PS	PS	1, 2	3			
		b) Visual check	Major	Visual	100%	PS	PS	PS	1, 2	3			
		c) D.P. test on major weld joints (as per drawing)	Critical	NDT	100%	PS	PS	PS	1	3	2		
1.10	Bearing & Bearing housings	a) Visual checks	Major	Visual	100%	PS	PS	PS	1	3	2		For bearing housings.
		b) Dimensions	Major	Measurement	1sample / lot	Mfg's. catalogue	Mfg's. catalogue	PS	1	3	2		
		c) DP test	Critical	NDT	On machined area			PS	1	3	2		
1.11	Power Terminal Box	Provisions made as per Spec clause no 5.7 of the specification	Major	Visual/Measurement	100%	Test Report	Test Report	PS		3	2	1	Review of type test report.
		b) Clearances, creepage distances of insulators	Major	Visual/Measurement	100%	Test Report	Test Report	PS	1	3	2		

QUALITY ASSURANCE PLAN
6.6kV INDUCTION MOTORS

SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY R	AGENCY P	AGENCY W	AGENCY H	REMARKS
		c) Review of type test reports	Major			Test Report	Test Report	PS	2	3		1	
		d) Compliance to type tested terminal boxes	Critical	Review		Test Report	Test Report	PS		3	2	1	
1.12	RTD, BTD or Dial type Thermometer (Mercuty in Steel)	a) Temperature calibration	Major	Measurement	1sample / lot	Manufacturing Drgs.	Manufacturing Drgs.	PS	2	3			
		b) Dimension	Major	Measurement	1sample / lot	Manufacturing Drgs.	Manufacturing Drgs.	PS	2	3			
		c) Accuracy	Critical	Measurement	1sample / lot	Manufacturing Drgs.	Manufacturing Drgs.	PS	2	3			
1.13	Space heaters	Verification of name plate details	Minor	Visual	100%	PS	PS	PS	1, 2	3			
		High voltage test	Major	Electrical	100%	PS	PS	PS	1, 2	3			
		Insulation resistance measurement	Major	Electrical	100%	PS	PS	PS	1, 2	3			
1.14	Coolers (if provided)	Verification of mechanical properties of materials used	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			
		Verification of chemical properties of materials used	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			
		Examination of welds, welding process, and welders	Critical	NDT	Sample	PS	PS	PS	1	3	2		Welding shall be performed by qualified welder(s) according to qualified welding procedure(s).
		Pressure testing	Critical	Testing	100%	PS	PS	PS	1	3	2		
		Verification of dimensions, location and size of nozzles, flanges	Minor	Measurement	100%	PS	PS	PS	1	3	2		

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY				REMARKS
									R	P	W	H	
1.15	Brakes (if provided)	Verification of mechanical properties of materials used	Major	Measurement	1sample / lot	AD	AD	AD	1, 2	3			
		Verification of chemical properties of materials used	Major	Measurement	1sample / lot	PS	AD	AD	1, 2	3			
		Examination of welds, welding process, and welders	Critical	NDT	100%	PS	AD	AD	1	3	2		
		Functional tests	Major	Testing	100%	PS	AD	AD		3	1, 2		
1.16	Reverse rotation ratchet (if provided)	Verification of mechanical properties of materials used	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			
		Verification of chemical properties of materials used	Major	Measurement	1sample / lot	PS	PS	PS	1, 2	3			
		Examination of welds, welding process, and welders	Critical	NDT	Sample	PS	PS	PS	1, 2	3			
		Functional tests	Major	Testing	Sample	PS	PS	PS	1, 2	3			
1.17	Neutral side current transformers (if provided)	Verification of ratings	Critical	Visual	100%	AD	AD	PS	1, 2	3			
		Review of routine test certificates	Major	Review	100%	IS	IS	PS	1, 2	3			
		Review of type test certificates	Major	Review	Sample	IS	IS	PS	1, 2	3			
1.18	Other accessories and auxiliaries	Review of test reports	Major	Review	100%	AD/ IS	AD/ IS	PS	1, 2	3			
		Review of environmental qualification reports	Major	Review	100%	AD/ IS	AD/ IS	PS	1, 2	3			
		Functional verification	Major	Testing	Sample	AD/ IS	AD/ IS	PS	1, 2	3			

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY				REMARKS
									R	P	W	H	
1.19	Fly wheel (if provided)	Verification of mechanical properties	Major	Measurement	1sample / lot	AD	AD	AD	1, 2	3			
		Verification of chemical properties of materials used	Major	Measurement	1sample / lot	AD	AD	AD	1, 2	3			
		Balancing	Critical	Measurement	100%	AD	AD	AD	2	3		1	
		Non Destructive Examination by Ultra sonic testing	Critical	Examination	100%	AD	AD	AD		3	2	1	
2	**INPROCESS INSPECTION**												
2.1.1	Fabricated / Cast frame/end shields	a) Blow holes/cracks	Major	Visual	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1	3	2		Welding to be done by Manufacturer qualified welders based on qualified procedures.
		b) Stress relieving	Major	Physical	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1	3	2		
		c) D.P. Test on weld joints of load bearing areas (as per the drawing)	Critical	NDT	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1	3	2		
		d) Dimensions	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1	3	2		
2.1.2	Machined fabricated frame and endshields.	a) Surface finish	Major	Visual	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1	3	2		Welding to be done by Manufacturer qualified welders based on qualified procedures.
		b) Measurement of run out/concentricity/PCD	Critical	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1	3	2		
		c) D.P. Test on load bearing areas (as per drawing)	Critical	NDT	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1	3	2		
		d) Dimensions	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1	3	2		
2.1.3	Machined bearing housing	a) Surface finish	Minor	Visual	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1, 2	3			
		b) Dimensions	Minor	Visual	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1, 2	3			
2.2	Shaft fabrication	a) M.P.I. Test on spider weld	Major	NDT	100%	PS	PS	PS	1, 2	3			

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY				REMARKS
									R	P	W	H	
		b) Stress relieving of weld joints (as per drawing)	Major	Physical	100%	PS	PS	PS	1, 2	3			
2.3	Machined Shaft	a) Dimensions	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1, 2	3			
		b) Surface finish	Major	Visual	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1, 2	3			
		c) D.P. Test on load bearing areas and shaft extension	Critical	NDT	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	2	3		1	
2.4.1	Brazed Rotor	a) D.P. Test on brazed joints	Critical	NDT	100%	PS	PS	PS	1, 2	3			Brazing to be done by qualified brazers based on qualified procedures.
		b) UT on brazed joints	Major	Physical	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS		3		1,2	
2.4.2	Rotor assembly completed	a) Major dimensions	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1, 2	3			
		b) Dynamic balancing of rotor	Critical	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	2	3		1	
		c)Runouts on bearing step and shaft extension	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1, 2	3			
2.5	STATOR							PS					
2.5.1	Stator Coils	a) Dimension checks	Major	Measurement	10%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1.2	3			
		b) Power freq. HV test on core portion & O/H portion	Major	Electrical	100%	PS	PS	PS	1	3	2		Witness by 2 on Sample Basis
		c) Impulse test 1.2/50 micro sec. earth insulation	Major	Electrical	2sample / lot	IEC-34-15	IEC-34-15	PS		3	2	1	
		d) Inter turn power frequency withstand test on cut and flared coil	Major	Electrical	2sample / lot	IEC-34-15	IEC-34-15	PS		3	2	1	
		e) Slot insulation stability	Major	Electrical	1sample / lot	PS	PS	PS		3	2	1	

QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS														
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY				REMARKS
									R	P	W	H	
2.5.2	Stator core (Before coil insertion)	a) Core length	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1.2	3			
		b) Check by slot gauge	Major	Measurement	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1.2	3			
		c) Hot spot test	Major	Electrical	100%	Manufacturing Drgs.	PS	PS	1	3	2		
		d) Visual check	Major	Visual	100%	Manufacturing Drgs.	Manufacturing Drgs.	PS	1	3	2		
2.5.3	Wound Stator (before impregnation)	a) Resistance	Major	Electrical	100%	PS	PS	PS	1, 2	3			
		b) Insulation resistance & PI	Major	Electrical	100%	PS	PS	PS	1, 2	3			
		c) Placement of RTD's	Major	Visual	100%	PS	PS	PS	1, 2	3			
		d) IR and resistance of RTD's	Major	Electrical	100%	PS	PS	PS	1, 2	3			Before and after VPI
		e) Interturn voltage test	Critical	Electrical	100%	PS	PS	PS	1, 2	3			
		f) Bracing of wdg. Overhang	Major	Visual	100%	PS	PS	PS	1, 2	3			
2.5.4	Impregnation	Process parameters	Critical	Visual	100%	PS	PS	PS	1, 2	3			
2.5.5	Wound stator (after impregnation)	a) Resistance	Major	Electrical	100%	PS	PS	PS	1, 2	3			
		b) Insulation resistance	Major	Electrical	100%	PS	PS	PS	1, 2	3			
		c) HV test	Major	Electrical	100%	PS	PS	PS	1, 2	3			
		d) Polarity	Major	Electrical	100%	PS	PS	PS	1, 2	3			
		e) IR & HV test on RTD's	Major	Electrical	100%	PS	PS	PS	1, 2	3			
		f) Measurement of tan delta and delta tandelta at higher temperarature.	Major	Electrical	Sample	AD	AD	PS	1, 2				
		g) Tan Delta & Delta Tan Delta at room temperature	Major	Electrical	100%	AD	AD	PS		3	2	1	

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY				REMARKS
									R	P	W	H	
		h)PI Test on stator winding	Major	Electrical	100%	PS	PS	PS	1, 2	3			
3	TESTS												
3.1	Completed Motor	a) Air Gap	Major	Measuring stator ID and rotor OD	100%	Manufacturing Drgs.	Manufacturing Drgs.	Test Report		3	2	1	
		b) Mounting and over all diemensions	Major	Mechanical	100%	Approved GA Drg.	Approved GA Drg.	Test Report		3	2	1	
		c) Runout of shaft extension, spigot and flange	Major	Mechanical	100%	Approved GA Drg.	Approved GA Drg.	Test Report		3	2	1	
3.2	Routine Tests	a) IR of winding before and after HV test	Major	Electrical	100%	IS 325/IS 4029	IS 325/IS 4029	Test Report		3	2	1	
		b) HV test	Major	Electrical	100%	IS 325/IS 4029	IS 325/IS 4029	Test Report		3	2	1	
		c) Resistance measurement	Major	Electrical	100%	IS 325/IS 4029	IS 325/IS 4029	Test Report		3	2	1	
		d) IR, HV, IR on space heater and winding RTD	Major	Electrical	100%	IS 325/IS 4029	IS 325/IS 4029	Test Report		3	2	1	
		e) Phase sequence & direction of rotation	Major	Electrical	100%	IS 325/IS 4029	IS 325/IS 4029	Test Report		3	2	1	
		f) Locked rotor test	Major	Electrical	100%	JEC 37: 1979	JEC 37: 1979	Test Report		3	2	1	
		g) Reduced voltage running test on no load	Major	Electrical	100%	IS 325/IS 4029	IS 325/IS 4029	Test Report		3	2	1	
		h) No load test and bearing temp. rise	Major	Electrical	100%	IS 325/IS 4029	IS 325/IS 4029	Test Report		3	2	1	
		I) Shaft voltage	Major	Electrical	100%	IS 325/IS 4029	IS 325/IS 4029	Test Report		3	2	1	
		j) Polarisation index	Major	Electrical	100%	IS 325/IS 4029	IS 325/IS 4029	Test Report		3	2	1	
		k) Noise level on No load	Major	Electrical	100%	IS 12065	IS 12065	Test Report		3	2	1	
		l) Vibration on No Load	Major	Electrical	100%	IS 12075	IS 12075	Test Report		3	2	1	

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS										
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY R	AGENCY P	AGENCY W	AGENCY H	REMARKS
		m) Functional checks on all accessories and auxiliaries						Test Report		3	2	1	
		n) Completeness	Major	Visual	100%	Approved GA Drg.	Approved GA Drg.	Test Report		3	2	1	
		o) Terminal marking and rating plate details	Major	Visual	100%	Approved GA Drg.	Approved GA Drg.	Test Report		3	2	1	
		p) Overspeed test at 120% rated speed for 2 min.	Major	Electrical	100%	IS/IEC	IS/IEC	Test Report		3	2	1	
3.3	Type Tests (In addition to all tests mentioned in routine test)	a) Temp. rise test at approx + 10% or - 10% of rated voltage, whichever is critical	Major	Electrical	On one motor	IS/IEC	IS/IEC	Test Report		3	2	1	
		b) Load test and derivation of performance data corresponding to 50%, 75% and 100% load at rated voltage	Major	Electrical	On one motor	IS/IEC	IS/IEC	Test Report		3	2	1	
		c) Operation of motor on full load at 70% voltage for 1 second & 80% voltage for 10 min.	Major	Electrical	On one motor	AD	AD	Test Report		3	2	1	
		d) Test for degree of protection by enclosures of motor and terminal box	Major	Mechanical	On one motor	IS/IEC	IS/IEC	Test Report		1, 2	3		
		e) Recording of motor terminal voltage decay after switching off of the input supply voltage											

		QUALITY ASSURANCE PLAN 6.6kV INDUCTION MOTORS											
SR. NO.	COMPONENT/MFG. STAGE	CHARACTERISTICS CHECKED	CATEGORY	TYPE/METHOD OF CHECK	EXTENT OF	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF	AGENCY				REMARKS
									R	P	W	H	
		f) Recording of motor speed decay after switching of the input supply voltage											
		g) Momentary overload test	Major	Electrical	On one motor	IS/IEC	IS/IEC	Test Report		3	2	1	
4.0	Pre despatch Inspection	a) Painting finish	Major	Visual	100%	Approved GA Drg.	Approved GA Drg.	PS		3	2	1	
		b) Review of end documents & issue of shipping release	Major	Review of all doc. For each motor	100%	Approved documents	Approved documents	PS		3	2	1	
5.0	If specified in Annexure-A, special tests required to demonstrate capability of motors to perform in the anticipated ambient conditions due to radiation, LOCA and MSLB shall be performed in accordance with an approved procedure and reports submitted to NPCIL. All other qualification and testing shall meet the pump specifications.												

13-9-11

PC-E-344

NUCLEAR POWER CORPORATION OF INDIA LTD.
(A Government of India Enterprise)

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TECHNICAL SPECIFICATION

FOR

PIPING FABRICATION AND ERECTION FOR NUCLEAR POWER PLANTS (PHWRs)

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Name Signature Date

(For Revisions see Revision Control Sheet)

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TITLE: TECHNICAL SPECIFICATION FOR
PIPING FABRICATION AND ERECTION
FOR NUCLEAR POWER PLANTS (PHWRs)

REV. NO. & DATE	DESCRIPTION OF REVISION	PREPARED BY	CHECKED BY	REVIEWED BY	APPROVED BY

1.0 SCOPE

This Specification describes the requirements of fabrication and erection of Piping and Equipments for the forthcoming NPP's (PHWR). It is to be read in conjunction with following NPCIL's Specifications.

PC-P-285: Technical Specification for field welding of piping for Nuclear Power Plants (PHWRs).

PC-P- 345: Cleaning Methods for Piping

The requirements are based on applicable Standards and Publications listed in Appendix-C of this specification. Reference to these Standards and Publications is required only to the extent and in the instances where called for in the specifications issued by the NPCIL. In the event that certain technical requirements are not described in the NPCIL specification, the Contractor shall request the NPCIL to issue governing requirements, prior to start any fabrication.

The NPCIL shall have the right to amend existing and to issue additional specifications whenever the need shall arise. All such specifications, whether in the form of specification, drawing, instructions or procedures will be issued consistent with the provision of the Contract Documents.

2.0 CONTENTS

The requirements of this specification are presented under the following headings:

		Section
Scope	:	1.0
Contents	:	2.0
Quality Control and Inspection	:	3.0
Discrepancies and Field Changes	:	4.0
Identification of Material	:	5.0
Manufacturer's Data	:	6.0

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Threads	:	8.0
Tightening of Bolts	:	9.0
Bending	:	10.0
Hangers and Supports	:	11.0
Grouting of Equipment	:	12.0
Testing	:	13.0
Painting of Pipe Lines & Equipments	:	14.0
Tube Erection	:	15.0
Instructions for Setting and Adjusting Constant Support and Variable Spring Type Hangers in the Field	:	APPENDIX-A
Dry Packing of Equipment	:	APPENDIX-B
Applicable Specification, Standards and Publications	:	APPENDIX-C
Installation of Concrete Expansion Fasteners	:	APPENDIX-D
System Test Requirements	:	APPENDIX-E
Torque Loads for Tightening of Stud Bolts	:	APPENDIX-F
Guide lines for Testing of Instrument Tubing (along with Instrument)	:	APPENDIX-G

3.0 QUALITY CONTROL AND INSPECTION

The Contractor shall be responsible for and shall provide for and perform all the inspection and testing required by NPCIL Specification.

The Contractor shall submit a Quality Assurance Plan and manufacturing procedure for approval together with the qualifications of his inspection and testing personnel. The contractor shall deploy trained and qualified manpower for inspection and testing. The write-up shall include all the steps to be followed for achieving the quality as required by the specification.

The Nuclear Power Corporation of India Ltd. (NPCIL) will be represented by a Quality Surveyor designated by Engineer-in-charge. The Quality Surveyor and his staff will be responsible for verifying the quality of work to the extent necessary to assess compliance with the provisions of the specifications. His surveillance may not be limited to examination of the end

product and he shall have complete access to the work and the right to intervene where the bad practice is suspected. He shall also have the right to conduct or require the Contractor to perform, at the departmental expense, any additional inspection or testing which he deems necessary. If any unacceptable defects are noted by such tests the contractor shall repair the defects without any charge to NPCIL.

The surveillance provided by the Quality Surveyor or the approval by the Engineer-in-charge for the finished work shall not relieve the Contractor of any of his responsibilities under this specification. The rejection of work not meeting this specification is possible at any stage during execution.

The Contractor shall maintain quality control records which shall record fully all the quality control operations that were performed. The Quality Surveyor shall have the right to witness any or all such operations.

4.0 DISCREPANCIES AND FIELD CHANGES

Any discrepancies or contradictions, omissions from drawings, specifications or other documents, or any doubts, arising as to the meaning or intent of any part thereof, shall be referred to the Engineer-in-charge. Written instructions or explanations will then be issued by the Engineer-in-charge as soon as possible. Verbal communications of decision / directives should be avoided.
All dimensions shown on the drawings which are related to install equipment or pertinent embedded parts shall be verified by the Contractor by field measurement before the fabrication of relevant pipe lines are started. The required dimensions of closing pieces of piping as indicated on the detailed drawings must be established by direct field measurements. Any deviation should be approved by Engineer-in-charge.

Whenever the Contractor is unable to comply with the Engineer's requirements, be it dimensional or technical, or whenever field changes are inevitable for any reason, the Contractor must obtain the appropriate authorization from the Engineer-in-charge. This authorization shall be in one or more of the following forms:

a) Amendment of applicable specification

b) Revision of applicable drawing.

c) Approval of Design Concession Request (DCR)

d) As built drawing – for very minor, non-consequential changes.

5.0 IDENTIFICATION OF MATERIAL

All materials to be used in piping installation shall conform with the specification issued by the Engineer-in-charge. No substitution of equivalent materials permissible unless approved through a DCR.

Manufacturer's certificates attesting compliance of the material with the specification shall be retained in the Engineer's record for the project. The certificate shall include identification details, a certified report of the results of all the required tests, examinations, and repairs performed on the material. Each piece of pipe, regardless of length, and each fittings or other component part, except minor fasteners, shall be clearly identified by legible marking on the part. The marking shall consist of the applicable specification number, Grade/Type, and any non-destructive testing. In those cases where size or shape prohibits, a marking code shall be used that identifies the material with the certification report.

When a part is cut to make more than one component the marking shall be transferred to all the pieces, such transfers to be authenticated by Quality Surveyor. Materials shall be marked by any method that will not result in any harmful contamination or sharp discontinuities and will identify the material until the system is completely installed. Material having thickness 6 mm and greater may be marked by stamping. When stamping is used, it shall be done with round-nose continuous or round-nose interrupted-dot low stress die stamps. Vibroetching is permitted on all thickness provided minimum wall thickness requirements are met and marking is acceptable to Quality Surveyor.

Pipe lines and sub-assemblies shall be identified in accordance with the code number assigned on the flow sheet.

C.S. &S.S. items shall be stored in specified segregated areas.

6.0 MANUFACTURER'S DATA

Proprietary designed equipment such as pumps, valves etc. are covered by the Manufacturer's manuals and these shall form a part of NPCIL's Specifications. The Contractor shall be required to perform any field work and adjustments as requested in the Manufacturer's Manuals. These manuals should be returned with the deviation marked (if any) by the Contractor on completion of the work.

7.0 GENERAL FABRICATION AND ERECTION REQUIREMENTS

7.1 All piping, equipment etc. shall be erected and joined or welded, utilizing materials in accordance with the drawing supplied by the Engineer-in-Charge. The free issue material (FIM) will be issued by the Engineer-in-Charge at the time of excuting the particular installation or as and when required.

7.2 Tolerance

7.2.1 Unless otherwise specified on the drawings, the following tolerances will apply and shall be achieved without springing into position.

72.1 Tolerances on dimensions shall not exceed ±3 mm and tolerances shall not be cumulative. Any deviations in excess of 3 mm from that required on the drawing, shall be brought to the attention of the Engineer-in-Charge.

7.2.2 The bolt holes of flanges in the vertical plane shall straddle the vertical centre line of the pipe in the erected position. For flanges in the horizontal plane, the bolt holes shall straddle the plant North – South axis unless otherwise indicated on the drawing.

The maximum deviation, measured in any direction, on flange face alignment shall be ½ degree or 0.8 mm whichever is less.

Maximum parallel misalignment on flanged joints shall be ±1.6 mm.

7.3 Pipe line shall be made with the minimum feasible number of joints. All longitudinal seams, where permitted, shall be staggered.

7.4 The Contractor shall shop fabricate sub-assemblies of piping etc. to the maximum extent feasible. These shop fabricated sub-assemblies shall be preserved to prevent corrosion, damage, etc. However, he must pay due attention to the cleaning procedure described in NPCIL specification No. PC-P- 345. It may so happen that the complicated assemblies are likely to hinder with adequate cleaning or allowing the inspection possible. however, in such cases of complicated assemblies, the same can be achieved in stages under controlled cleanliness requirements. In addition to the requirements of Specification PC-P- 345, the clean white lint free hand gloves and shoe covers shall be used in clean shop conditions. Also for feeder work in F/M Vault, SS work in Moderator room and all work in Calandria Vault, clean white overalls, hand gloves and shoe covers shall be used.

7.5 Wherever the PSI of joint/s is called for, the weld edge preparation of pipe spools, fitting and valves shall be in accordance to PC-P-285.

7.6 All machined surfaces shall be protected from dirt and mechanical damage. All threaded connections shall be either capped or have threaded plugs inserted until the associated equipment has been installed. No liquids of any kind, whether for cleaning, testing or other reasons, shall be admitted to the pipe lines or the equipment except when authorized by the Engineer-in-Charge.

7.7 Loading and unloading of materials and equipment shall be by hoisting or skidding so as to avoid shock or damage. Under no circumstances the materials shall be dropped. Pipe handled on skidways shall not be skidded or rolled against other pipe.

7.8 The equipment, arriving at site, shall be immediately inspected, classified and directed to such storage as may be necessary for its protection.

7.9 The Contractor shall visually examine all materials being erected or being used in the fabrication and shall report the defects to the Engineer-in-charge. Any repair of materials shall be as per the instructions of the Engineer-in-charge. Any material not conforming to the specification and rejected by at any stage should be suitably identified & isolated subsequently and stocked at separate area identified as "Rejected Material" and later on disposed off as per the instructions of the Engineer-in-charge.

7.10 The equipment surface/areas from where the temporary attachments have been removed shall be dressed smoothen and shall be examined by a magnetic particle or liquid penetrant method. Defects, if any, shall be removed and the material shall be reinspected to ensure that the defects have been removed completely. If weld repairs are necessary, they shall be made using qualified welding procedures and qualified welders and shall be examined by a magnetic particle method, liquid penetrant method, or by radiography as the Engineer-in-charge may direct.

7.11 All gaskets, diaphragms, seals etc. shall be removed from valves and other equipments and shall be properly identified, stored and reassembled by the Contractor under the supervision of Engineer-in-charge, whenever welding is likely to damage them.

7.12 Gouging and gas cutting operation shall be done by qualified personnel. All material in the surrounding area should be suitably protected during welding, gouging and gas cutting operation.

7.13 Valve care and Testing at Site

7.13.1 Adequate care shall be taken during welding of valves. Valve manufacturer's instructions, if any, shall be followed in this regard. Contractor shall take due care and adopt proper welding sequence to avoid distortions of valve seat and body etc. Any repair work required on installed valve shall be carried out by the contractor to limit the seat leakage rates to those specified by valve manufacturer. Valves are received at site after their acceptance by NPCIL, QS Engineer along with the respective test certificates for conformance to technical requirements and shipping release issued. All tests required as per applicable valve specification sheet shall be carried out at manufacturer's works. At site, to facilitate construction activity and to cross check any deterioration during transit / storage, valves may be tested for seat leakage as a pre installation check, if felt necessary to minimize the chance of reworking on erected valves. However, all relief valves and safety relief valves shall be set at specified set pressure at site Valve Testing Facility (VTF). Valve testing facility shall be arranged by contractor. It is advisable to shop fabricate the system boundary of valve along with the make-up piece/s, inspect the sub-assembly and then install the sub-assembly finally in the field. Generally, valves should be welded in crack open position and heat input kept to minimum.

7.13.2 For the ease of testing it is acceptable that hydrostatic testing of valves may be replaced by pneumatic testing up to test pressure 100 psi(g) only, provided due safety precautions are taken.

7.13.3 Frequency of calibration of pressure gauges used for testing of leak tightness of valves at site VTF only may be kept three months or whenever there is a reason to believe that calibration has got disturbed.

7.13.4 After testing of valves, same shall be properly cleaned, dried with oil free compressed air, capped / packed in polythene and properly stored till they are erected on lines.

7.13.5 Setting of Relief Valves / Safety Relief Valves

All relief valves / SRVs shall be set at specified set pressure at site VTF and a report duly signed by NPCIL QS to be issued. For this purpose validity of pressure gauges shall be 15 days for systems conforming to ASME Section III, NB, NC & ND.

7.14 Care during Welding

7.14.1 Utmost care shall be taken while carrying out welding job on equipment nozzle. particularly heat exchangers etc. so that no weld spatter etc. falls inside the equipment. This specific requirement has to be met in all heavy water system in general and particularly PHT main circuit and Moderator System inside Calandria vault. Contractor shall prepare check list / procedure to ensure that no foreign objects are left inside the piping at any stage of fabrication. Fibroscopic / Boroscopic examination and supervisors clearance with signed check list may be required before closure of pipe joints. Engineer-in-Charge may ask for additional examination to be carried out on completed portions of the piping if he suspects presence of any foreign object. In case the foreign object is found, the same shall be removed and joints / piping shall be remade without any extra cost to the NPCIL.

7.14.2 The Contractor will take adequate care to prevent damage to bellows (e.g. floor penetration bellows and expansion joints etc.) during storage, handling and erection. The bellows shall be stored with their original shipping frame and protective arrangement and shall be brought to site as the last item, just prior to their incorporation in the system.

7.14.3 They shall be protected with asbestos cloth and G.I. sheet to the satisfaction of Engineer-in-Charge prior to shipment to the place of installation. This protection shall remain during and after welding/erection till the system is accepted by the Engineer-in-Charge. In case where this protection is required to be removed due to sequence of installation, additional cover/protective arrangement in that area shall be made by the contractor as directed by the Engineer-in-Charge. This arrangement shall also remain intact till the system taken over by the Engineer-in-Charge.

7.14.5 House Keeping / Material Handling

The Contractor shall ensure proper house keeping, preservation of material, proper material handling and material movement in the plant site, in an acceptable manner to NPCIL

8.0 **THREADS**

Threading of pipe shall be done after bending, forging or heat treating operations, if any. Pipe threads shall generally conform to ANSI B 1.20.1, BS-21, IS-554. For EPs / threaded bolts coarse pitch as per IS-4218 may be used. The Contractor shall be responsible for threading on all mating

components to suit the threads on valves, pipe fittings and equipment flange bolting, studs, nuts and mounting bases.

Matching threads of hanger components supplied or fabricated by the Contractor may be threaded to any commonly accepted standard unless otherwise specified on drawings; however, the same thread standard must be used throughout and shall be subjected to the approval of Engineer-in-Charge.

The threads shall be cut with a sharp and properly adjusted threading tool to the correct taper, lead, thread angle and diameter. Rough, wavy, sheared or improperly made threads of any description shall be removed from the pipe and new threads shall be made to the satisfaction of the Quality Surveyor. Threads shall be concentric with the outside barrel of the pipe. Pipe thread diameters shall be such as to allow sufficient hand engagement and yet allow enough threads for wrench-up to produce a tight joint. All pipe threads shall be cut on machine only and shall be checked with National Bureau of Standards approved gauges and shadow graphs.

Prior to making a screwed joint, the threads shall be thoroughly cleaned off for all the foreign matters, oil, grease etc. Any thread that has become blurred or deformed shall be repaired prior to assembling the joint. If the thread is damaged to the extent that it cannot be repaired without sacrificing the tightness of the joint, then the threaded end shall be removed from the pipe and new threads made to the satisfaction of the Engineer-in-Charge. No lubricants or sealants shall be used on threaded joints of any pipes in the Reactor Building carrying water, heavy water or helium / cover gas.

Similarly, screwed joints coming in the piping system for Secondary system and Common Services system inside the Reactor Building shall be seal welded except at the equipment terminal point. This includes seal welding of the instrument root valves. These joints shall be made dry and seal welded (carbon steel to carbon steel, stainless steel to stainless steel or carbon steel to stainless steel), seal soldered (carbon steel to bronze) or seal brazed (copper to bronze). Seal welding at the equipment terminal will be decided on individual basis and intimated to the contractor. However, no seal welding shall be carried out at the hose valve and bronze valves in the domestic water system and compressed air system.

Wherever seal welding of screwed joints in a piping system is called for, the same shall be carried out in accordance with a proper procedure. Before seal welding of screwed joints the unengaged threads on pipe shall be removed by grinding / filing.

On all other systems, lubricant (approved by the Engineer-in-Charge) shall be so applied as to cover evenly all threads on the male member of joint. On copper lines, and GI lines "Teflon" tread tape 0.127 mm thick shall be used for making threaded joints.

9.0 TIGHTENING OF BOLTS

a) All bolts shall be engaged so that there is visible evidence of complete threading through the nut or threaded attachment. At least two threads on bolt should project beyond nut.

b) In bolting of gasketted flanged joints, the contact faces of the flanges shall bear uniformly on the gasket, and the gasket shall be properly compressed in accordance with the design principles applicable to the type of gasket used. The bolt stress in all flanged joints shall be relatively uniform.

c) All threads of the nut and bolts shall be cleaned by suitable means so as to be free from any foreign materials and suitable approved lubricant whenever specified shall be used prior to tightening of bolts.

d) Torque Wrenches shall be used for tightening of bolts to ensure the controlled tightening.

e) Torque values for various sizes of bolts for tightening are specified in Appendix-F. These values are to be taken as guide lines for tightening the bolts. However, the exact torque required for tightening will be indicated by the Engineer-in-Charge, taking into account inter-alia the material of the bolts and gaskets to be used in the joints. Over-tightening of threaded joints shall be avoided and need to do so shall be intimated to the Engineer-in-Charge. The bolts shall be pre-tightened in such a way that gaskets are subjected to minimum compression as required by gaskets manufacturer recommendations. To achieve minimum compression of gaskets, the bolts can be subjected to stress which are around 60% of yield stress of the bolt material.

10.0 BENDING

Cold bending will be done using formed dies, and with internal mandrels (wherever practically feasible), to prevent flattening. Compression-bending shall be used for thick wall pipes and for large radius bends, as interpreted by the Engineer. "Draw" bending shall be used for thin wall pipes and for small radius bends, as interpreted by the Engineer-in-Charge. The use of any filler material during bending is prohibited. Hot bending is not permitted, except that minor hot bending correction may be permitted as directed by the Engineer-in-Charge. Any bending lubricants shall be subjected to approval

of the Engineer-in-Charge. In specific cases, induction heating of the pipe and bending may be permitted with approval of the Engineer-in-Charge.

Bend curvature shall be uniform and the surfaces shall be free from cracks, bulges, wrinkles, tooling damage and other injurious defects.

At any section of the formed pipe, the wall thickness shall not be less than 87.5% of the nominal wall thickness, and the difference between the major and minor outside diameters shall not exceed 8% of the nominal pipe diameter.

As required by the quality surveyor, sample bends shall be prepared and examined after sectioning for conformance with thickness and ovality requirements.

The entire external surfaces of all bends of heavy water systems shall be inspected by a liquid penetrant technique. For other systems liquid penetrant examination shall be carried out on 10% of the bends. The wall thickness of 4% of bends in Feeders, Primary system and Fuel Transfer system shall be checked by Ultrasonic guaging technique. For Feeder bends before starting production bending, the Contractor shall prepare three sample pipe bends for each size and minimum specified bend radius for each size, using the material specified and the proposed manufacturing procedures and tooling. Samples shall be examined by the methods specified for production bends and by Sectioning.

11.0 HANGERS AND SUPPORTS

a) The steel surfaces of supports and hangers located in Nuclear Island shall be cleaned by abrasive blasting.

Other hangers and supports shall be cleaned at least by wire brushing and coated with primer plus two finishing coats of paint approved by Engineer-in-Charge prior to shipment to the site. Touch-up to the paints, damaged during transportation / erection will be given by the Contractor after installation. The embedded parts (EP's) such as plates, bolts, angles, channels which have been provided in the concrete floors, walls, column and beams etc for installation of pipe and equipment supports, wherever such EPs are not adequate or the supports are to be fastened at different locations other than where EPs for these supports are provided, in such cases the supports are to be fastened either by means of concrete expansion fasteners or with the help of channel inserts. installation of concrete expansion fasteners shall conform with the requirements of Appendix-D of this specification.

In some cases, channel inserts are embedded in concrete ceilings and wall of the building. The detailed installation drawings for these inserts, if provided, shall be made available to the contractor.

Spring, roller and constant type supports shall be adjusted by the contractor on completion of installation as per the Manufacturer's recommendations. Appendix-A gives the general guide lines for installation of these supports.

The forged components of hangers and supports shall be subjected to visual inspection to ensure good workmanship.

Where slope of the pipe for draining is mentioned in the drawings, proper care shall be taken to maintain the slope during installation of support.

Where Carbon Steel (CS) supports were used for SS pipe. SS / brass shim sheet shall be used between pipe and support clamp.

b) Shock Arrestors (Snubbers)

Where snubbers are to be used in piping system and equipment or any other component, installation of the same shall be done as per the procedure approved by the Engineer-in-Charge. The purpose of the snubber is to protect the component against dynamic loading, e.g. those during earth quake and/or pipe rupture events. The snubber shall allow essentially free movement of the component where the component is subjected to non-dynamic loads such as that imposed by thermal expansion and contraction. Before installation, the snubbers shall be checked for their functionability i.e. compression / expansion / free movement.

12.0 GROUTING OF EQUIPMENT

Grouting of equipment, wherever required, shall be done in accordance with procedure described in Appendix-B.

13.0 TESTING

After the completion of fabrication and erection of the piping system, the same shall be subjected to pneumatic / air hold testing, hydrostatic testing and helium leak testing as per the requirements of Appendix–E of this specification. The contractor shall arrange suitable type / range of safety relief valves for hydro/pneumatic testing in consultation with Engineer –in-Charge.

Pneumatic testing of all circuits including heavy water systems shall be done by the Contractor. Compressed air / nitrogen cylinders shall be arranged by Contractor at no extra cost.

The hydrostatic testing and helium leak testing of various systems shall be done by the contractor under the supervision of Engineer-in-Charge. The Contractor shall arrange for blanking and requisite facilities to carry out the test and to inspect every joint. For helium leak testing, helium cylinders, leak testing machine and machine operator would be provided by Engineer-in-Charge. The scope of helium leak testing for heavy water system piping is included in Appendix–E. During hydrostatic testing the pipe lines shall be protected against corrosion which is a potential damage to the piping system. Both internal and external protection shall be provided to the piping system. Internal protection shall be provided by the injection of inactive volatile corrosion inhibitor. This corrosion inhibitor shall be approved by Engineer-in-charge.

The Contractor shall witness the test and do repairs as required. For convenience of testing, a system will be sub-divided into various circuits. For the sake of testing, many isolation points may be required. The contractor shall provide all such points and carry out any isolation job as desired by the Engineer-in-Charge.

The Contractor shall be issued a written procedure by the Engineer-in-charge, as how to isolate specific items from the system or how to sub-divide or isolate the sub-system. The contractor shall carry out the testing accordingly. The test pressures are stated in Appendix 'E'.

Areas where soap solution, masking/tapes and other adhesive tapes are used shall be cleaned by the Contractor using suitable solvents.

14.0 PAINTING OF PIPE LINE AND EQUIPMENTS

All the equipments, piping and supports shall be painted with appropriate approved painting system. Colour scheme / identification scheme shall be in conformance to NPCIL specification No. PP-E-1864. Following guidelines shall be followed.

a) Painting System for Radiation Areas (Zone–2, Zone–3, Zone–4 areas)

All the equipments, piping and associated supports in Zone–2, Zone–3, Zone–4 areas i.e. Reactor building, Reactor Auxiliary Building, Service Building, etc., shall be painted with approved epoxy painting system. Surface preparation for painting shall be as per the respective

manufacturer's recommendations, and a total coating thickness of 250 micron (min.) shall be achieved. Painting system shall be in conformance with NPCIL Specification No. PP-M-1219(Epoxy) and PP-M-1729(Inorganic zinc silicate primer). Following is the list of approved epoxy painting systems. List of qualified epoxy coatings for use on steel surfaces in RB and other main plant structures where epoxy coating has been specified.

Sl. No.	Description	Qualified Epoxy Coating System	Manufac-turer	Remarks
1)	Steel surfaces in F/M vault & F/M service areas in RB	Dimet coat-6 (inorganic zinc silicate primer) + Amercoat-90 (epoxy paint)	M/s. Goodlas Nerolac	Surface preparation shall be done by Abrasive blasting
2)	Abrasive blasted steel surfaces other than those mentioned at sl. No.1.	i) Apcosil-605(85%)PC2119 (inorganic zinc silicate primer) + ApcodurCF641 (epoxy) OR ApcodurCF641-CS (epoxy)	M/s. Asian Paints(I) Ltd.	
		ii) Zinc anode-304 (Inorganic Zinc Silicate Primer) + Protectmastic (High Build Epoxy paint)	M/s. Berger Paints	
		iii) Intergard 1054	M/s. Akzo Nobel Paints	
3)	Non-shot blasted (Hand tool cleaned) steel surfaces (steel surfaces shall be prepared to ST-2 finish prior to	i) Apcodur CF-641 CS	M/s. Asian Paints	Use of these coatings on non- Abrasive blasted steel

Sl. No.	Description	Qualified Epoxy Coating System	Manufac-turer	Remarks
	application of primer)	ii) Protectomsatic	M/s. Berger Paints	surfaces is only a compromise and shall be adopted only at locations where Abrasive blasting is not possible due to site constraints.

b) Painting Systems for All Others Areas (except radiation areas and wherever special painting systems are specified)

All the equipment, piping and associated supports in all the buildings except radiation areas as indicated in para (a) and for the areas where special / specific painting system are recommended (eg. Acid / Alkali resistant paints, painting system for saline atmosphere etc.,) synethetic enamel painting system shall be adopted. These painting system shall comprise of suitable surfaces preparation as per manufacturer's recommendation followed by application of Zinc Chromate / Zinc Phosphate primer conforming to relevant IS codes (refer IS 104 & IS-2074) and synthetic enamel coating conforming to relevant IS codes (refer IS 2932 & IS 2933). A total coating thickness of 150 micron (min.) shall be achieved.

c) Painting Systems for the Areas Requiring Specific / Special Painting System

Equipments, piping and associated supports in few specific / special areas may require specific painting system as per NPCIL's recommendation. Examples of some of such areas are:

i) Areas / systems requiring Acid / Alkali resistant painting system e.g. DM plant, chlorination plant, battery rooms, etc.
ii) Areas / Systems requiring heat resistant paint and high temperature paint.
iii) Areas / Systems requiring special paints for saline atmosphere.

15.0 TUBE ERECTION

15.1 Pre-requisite

S.S. Tubes, S.S. / Brass Shims, Nylon fishing thread of 2 mm dia., Acetone (Industrial Grade), Lint free flannel cloth, scissors, shim cutters, Tube storage racks, tube cutters, tube benders, tube clamps, spacers, M5 screw, nut & washers, installed light channel and supports, process tapping points, tag plates & S.S. wire, plastic caps, stickers, marker pens, 1 mm thick polyethene sheet, ladder and scaffolding, soap solution and spray bottle.

15.2 Description

15.2.1 Transportation and Cleaning of S.S. Tube

S.S. Tubes are available in 6-8 mtrs length and are to be stored in covered dust free shed. Transportation of these shall be carried out in aluminium PVC fixture to avoid sagging and bending of the mill length tubes by 3 or 4 persons or in any other suitable way so that tubes do not appreciably sag, and shall not be subjected to scratch. Handling of S.S. tubes should be properly supervised to avoid the above mentioned pitfalls.

Lint free flannel cloth is usually available in 1 mtr. width roll. This should be cut into square pieces of 30 mm x 30 mm size (approx.) Tubes shall be cleaned with lint free flannel cloth dipped in acetone and pulled through the tube, using Nylon fishing thread 3 or 4 times or till all dirt / dust is removed to the satisfaction of the Engineer. As a check for thorough cleaning of tubes, a lint free cloth shall be pulled through the tube and it should come out clean. This is to be done in presence of the representative of Engineer. Outer surface of the tubes shall be cleaned by rubbing the tubes manually with lint free cloth soaked in acetone. Cleaned tube shall be kept capped tightly all the time. Stickers will be put on cleaned tube, for identification. THESE STICKERS IDENTIFICATION SHALL BE REMOVED ONCE THE TUBES ARE LAID IN FIELD.

15.3 Cleaned Tube Storage

Cleaned tubes shall be stored on properly established tube storage racks. While storing, the tubes shall be supported at intervals not exceeding 1.75 Mtrs. Also the S.S. tubes should not come in contact with any M.S. items of storage tacks. M.S. parts of racks shall be covered with polythene sheets or any soft material viz. plywood, thermocol, etc. Clean room condition shall be maintained in the storage and prefabrication area.

Rejected tubes which are having scratches or pin holes etc should be stored separately from the accepted and cleaned tubes.

15.4 Fabrication and Laying of S.S. Tube

15.4.1 S.S. tube shall be laid as per the applicable drawings. Drawing shall be used only for guidance and detailed routing shall be finalized in consultation with the Engineer. Changes made, shall be incorporated in the as built drawings.

15.4.2 Prior to undertaking actual execution a tube layout diagram shall be prepared to determine the number of tubes in the tube bundles, then length and location of tube joints. Proper care shall be taken to minimize the tube wastage during fabrication and laying of tubes. Care in determining the tube run will save time and possible re-running at later date. While finalizing the routes, care should be taken for possible physical damage which can occur due to inadvertent working of individuals over it, falling of heavy material or using them as support for climbing.

15.4.3 As far as possible the tubes shall be prefabricated in the fabrication shop. The fabrication shop shall be clean and dust free and polythene sheets shall be spread wherever tubes are handled.

15.4.4 Tube cutting shall be carried using approved brand of tube cutters. Tube cutting shall not create any flattening or ovality of tubing at the point of cutting.

15.4.5 Approved brand of tube benders of appropriate size shall be used for bending of different sizes of tubes. Table is given for minimum bending radius for different sizes of tubes. Brand of tube benders shall be approved by NPCIL.

Tube size	Bending Radius
6 mm OD Tube	25 mm
10 mm	40 mm
12 mm	50 mm
20 mm	76 mm
25 mm	90 mm
¾ mm	3 inch
1 inch	3½ inch

15.4.6 Bends shall be made very carefully to the exact angle required. No flattening is allowed at the bends. Opening of the bends shall not be permitted in any case and any tube which has been wrongly bent shall be scrapped. The contractor shall store scrap tubes separately for his accounting.

15.4.7 Each length of prefabricated tube shall have the line number on it (The line number shall be written on the paper and stuck onto the tube with transparent adhesive tapes) for proper identification.

15.4.8 The prefabricated tube shall be bundled layer wise by using S.S. strips and wrapped with polythene sheets. Then this shall be transported to the site for laying.

15.4.9 All the prefabrication involving cutting and bending shall be as per applicable drawings. Prefabrication shall be done in such a way that when laid in the field, there shall be atleast 150 mm overlap between adjacent sections of the tubes or between tubes and instruments / equipments where it will be terminated to facilitate cutting and edge preparation. As already stated, cutting shall be so planned (and shall be dictated only by restrictions of transportation and laying) to keep the number of joints bare minimum.

15.4.10 Field fabrication and fabrication after laying shall be kept bare minimum.

15.4.11 Slope shall be maintained as per the instructions provided in the drawings. Downward slope from the take-off point to the instrument is maintained for liquid and steam, upward slope from take-off point to the instrument for gaseous fluid. If the instructions regarding slope is not given in the tube layout drawing, at least 1:20 slope either upward or downward as the case may be should maintained. Instructions mentioned in the drawing or any other instruction given by the Engineer shall be strictly followed.

15.4.12 Tubes shall always be laid preferably in light channel in vertical plane. Details of respective IEP's may be obtained from C&I group.

15.4.13 Tube projection in air shall be kept minimum.

15.4.14 If joints coming in tube bundles are of swaged type, then all those joints shall be properly staggered to facilitate easy assembly and disassembly in future.

15.4.15 No bend shall be made in the close proximity of welded joint and minimum 3 D clearance shall be provided from the welded joint while making bends.

15.5 Clamping of Tubes

Standard type of SS clamps shall be used to clamp the tubes. These clamps shall be used at distance not more than ¾ mtr. Clamps shall be fixed near the unions, tees, take-off points, termination points, near tube bends and off-sets, so that mutual separation of tube is avoided .