VOLUME – IA
PART I & II

TECHNICAL CONDITIONS OF CONTRACT (TCC)

S

BHARAT HEAVY ELECTRICALS LIMITED

CONTENTS

SL NO	DESCRIPTION	CHAPTER	NO. OF PAGES
VOL IA	**PART-I: CONTRACT SPECIFIC DETAILS**		
1	Project Information	Chapter-I	1
2	Scope of works	Chapter-II	9
3	Facilities in Scope of Contractor / BHEL (Scope Matrix)	Chapter-III	7
4	T&Ps and MMEs to be deployed by Contractor	Chapter-IV	7
5	T&Ps and MMEs to be deployed by BHEL on sharing basis	Chapter-V	1
6	Time Schedule	Chapter-VI	5
7	Terms of Payment	Chapter-VII	2
8	Taxes and Duties	Chapter-VIII	2
9	Bill of Quantity	Chapter-IX	1
10	General	Chapter-X	1
11	Accounting of materials	Chapter-XI	8
12	Progress of work	Chapter-XII	2
13	Material Handling	Chapter-XIII	2
VOL IA	**PART-II: TECHNICAL SPECIFICATIONS**		
1	Corrections / Revisions in Special Conditions of Contract, General Conditions of Contract and Forms & Procedures.	Chapter-1	03
2	General Technical Specifications and Borelog data (Book 1of2)	Chapter-2	455
3	General Technical Specifications and Borelog data (Book 2of2)		217
4	Drawings	Chapter-3	11
5	Technical Specification of Labour Colony	Chapter-4	10
6	No Deviation Certificate (Rev. 01)	Chapter-5	01
7	"HSE Plan for Site Operations by Subcontractor" (Document No. HSEP: 14 Rev01)	Chapter-6	82
8	Format for Form no.: F-14 (Rev 01); Monthly Plan and Review with Contractors	Chapter-7	05
9	Format for Form no.: F-15 (Rev 03); Monthly Performance Evaluation of contractor	Chapter-8	08
10	Pro forma for Bank Guarantee (in lieu of Security Deposit)	Chapter-9	03
11	Procedure 2.3-Procedure For Conduct Of Conciliation Proceedings	Chapter-10	11
12	T&P Hire Charges (Valid upto 31.08.2023)	Chapter-11	12
13	Proforma for Bank Guarantee (in lieu of Earnest Money)	Chapter-12	03
14	Proforma for Bank Guarantee (in lieu of Retention Amount)	Chapter-13	03

VOLUME-IA PART – I CHAPTER – I
PROJECT INFORMATION

1.1.1. INTRODUCTION

5 x 800 MW Yadadri Thermal power station is being set up by **TELANGANA STATE GENERATION CORPORATION** at a site in Veerlapalem village, Dameracherla Mandal, NALGONDA DISTRICT, TELANGANA STATE, India. The Bidder shall acquaint himself by a visit to the site, if felt necessary, with the conditions prevailing at site before submission of the bid. The information given here in under is for general guidance and shall not be contractually binding on BHEL/Owner. All relevant site data /information as may be necessary shall have to be obtained /collected by the Bidder.

1.1.2. PROJECT INFORMATION

S. NO.	DESCRIPTION	DETAILS
1.	Name of the Project	YADADRI Thermal Power Station
2.	Station Capacity	5X800 MW (Coal based)
3.	Owner	Telangana State Power Generation Corporation Limited (TSGENCO)
4.	Site Location	Site is located 7 km from the SH 2 Miryalaguda - Vadapalle Highway.
5.	Latitude	*16° 42'*20.40 N
6.	Longitude	79° 34'41.56 E
7.	Nearest Town	30 Km Miryalaguda
8.	Nearest Railway Station	6.5 Km Damercherla
9.	Nearest Airport	130 Kms (Vijayawada)
10.	Site Conditions	
11.	Ambient Temperature	
	Daily minimum (average)	10°C
	Daily maximum (average)	47°C
	Design Ambient Temperature	50°C
	Ambient temperature (performance)	38°C
12.	Relative Humidity for design / efficiency	48-84 %
13.	Annual rainfall, mm	600 mm
14.	Plant Elevation above MSL	85 m above MSL
15.	Mean Wind Speed	8 km/h
16.	Wind Pressure	As per the latest revision of IS 875/1987
17.	Seismic co-efficient	Zone-II as per IS- 1893 (Part-IV)

VOLUME-IA PART – I CHAPTER – II
SCOPE OF WORKS

1.2.1. The scope of works all Civil (Balance works), architectural, Mechanical, Electrical, C&I, works of Natural Draught Cooling Tower, NDCT 4 of 5X800 MW Yadadri Super Critical Thermal Power Project site including supply of materials for civil **(excluding Cement, Structural steel & Reinforcement steel for civil works)** Mechanical, Electrical & C&I works required, all labour, tools & plants. **(BHEL shall provide cement & reinforcement steel for civil works and structural steel for structural works only for incorporation in the permanent works as free supply)**

1.2.2. The scope of work includes supply, construction, erection and commissioning excluding engineering including supply of complete bought out materials, hot water distribution system up to battery limit, cold water basin and outlet channels up to battery limit, sludge pit, stair case from ground level to water distribution level & top of CT and all other equipment and accessories as mentioned herein after.

"Note: The NDCT contractor is required to own the owner approved thermal design and GA drawing such that the responsibility of cooling tower performance shall remain with the bidder in all manners. Any questions or clarifications regarding thermal design may be sought by the NDCT contractor to satisfy himself of its veracity. The tentative quantities for thermo- hydraulic components (Fills and distribution system) listed for S. nos. 24 and 25 of price bid as per BHEL's design indicated in Annexure-1 of section IA (page no. 61 of 454 of technical specification (book 1 of 2)) and the same is calculated based on the area inside the NDCT at respective levels shown in the GA drawing. If found necessary, "the NDCT contractor may suggest modifications to the thermos-hydraulic components (listed at S. Nos. 24 and 25 in the price bid) with technical reasoning/ analysis/ calculations to justify the measures to improve the thermal performance of the NDCT which will be guaranteed by the bidder" and such the responsibility of cooling tower performance shall remain with the bidder in all manners.

While suggesting justifiable reasons for changes as above the NDCT contractor shall abide by the following constraints. Also, the NDCT contractor shall guarantee the NDCT performance considering the constraints that are inviolable.

1) Civil design of NDCT shell, shell profile and shell dimensions at various heights
2) Foundation of NDCT
3) Air inlet height

4) Basin & internal structure column- beam grid dimensions and elevations
5) Water distribution ducts
6) Layout of CW hot water inlet header to cooling tower
7) Height and diameter of NDCT

Once the changes with justifiable reasons/ analyses / calculations provided by the NDCT contractor are accepted by BHEL/ consultant and duly incorporated, the NDCT contractor will vet the final thermal design & GA of NDCT and furnish the performance guarantee. The thermal design and GA vetted by the NDCT contractor shall be furnished to customer for approval. The NDCT contractor shall vet the thermal design as above within two weeks of award of contract, for further approval by BHEL/ customer.

The GA drawing already approved by owner may be required to be approved again depending on changes to the thermos-hydraulic components, if any and the NDCT contractor shall furnish the relevant modifications agreed to by BHEL/ customer to these items (only) keeping the other dimensions frozen for further approval from BHEL/ customer.

The complete design and engineering of NDCT shall remain in the scope of BHEL's consultant.

All mechanical/ electrical/ C&I drawings prepared by BHEL consultant will be reviewed by NDCT contractor before submission to customer for approval.

The NDCT contractor is required to estimate the "lump sum" cost of the thermo-hydraulic components. This lump sum rate towards the item no. 24 & 25 are firm and NDCT Contractor cannot claim any extra compensation in case of any increase or decrease of quantity against these two items.

No change in the quantities and cost of thermo- hydraulic components shall be allowed during execution due to any reason whatsoever from that quoted during tender stage.

NDCT Contractor who quotes as per BHEL thermal design, should submit the Guarantee Schedule in the Technical Specification with reference no. SPEC. NO.: PE-TS-417-165-N002, SECTION: III, REV.NO.0, SHEET 1 OF 1.

NDCT Contractor is allowed to Modify the thermo-hydraulic components as per Clause no. 1.01 of Section-I of Technical Specification & Clause 1.2.3 of Scope of works, Technical Conditions of Contract, only when the NDCT Contractor proposes for the improvement of the 'Guaranteed Cold water temperature'. If NDCT Contractor proposes to modify the Thermal Design, he should submit the Guarantee Schedule in the Technical Specification with reference no. SPEC. NO.: PE-TS-417-165-N002, SECTION: III, REV. NO.

01, SHEET 1 OF 1. Any calculation submitted by NDCT Contractor along with the offer supporting the reduction of cold water temperature will be treated as reference only. The NDCT Contractor shall submit the calculations to BHEL Engineering Department during detailed Engineering stage only for review and approval.

The calculations will be approved by Engineering department of BHEL during detailed Engineering and shall be binding on the NDCT Contractor.

In case, if BHEL is not satisfied with the calculation and NDCT Contractor has failed to support their calculation for the proposed guaranteed temperature, then the NDCT Contractor is bound to accept the BHEL's thermal calculations as per tender conditions.

If NDCT Contractor does not meet the Guaranteed Cold Water Temperature offered by the NDCT Contractor as per the SPEC. NO.: PE-TS-417-165-N002, SECTION: III, REV. NO. 00, SHEET 1 OF 1 (or) SPEC. NO.: PE-TS-417-165-N002, SECTION: III, REV. NO. 01, SHEET 1 OF 1, as applicable, then LD shall be levied as per Cl. No. 11 of Technical Specification.

It is not the intent to list all details herein, scope of supply listed in brief as follows:

I. MECHANICAL:

a. Incoming hot water piping, including vertical run, supported on cooling tower, motorized butterfly valves on hot water risers. Terminal point for hot water pipe shall be as per enclosed NDCT GA drawing. Welding at terminal point shall be in bidder's scope. Bidder shall also supply a pressure gauge & temperature gauge at the terminal point. Any reducer/ expander required at the terminal point shall also be in the bidder's scope.

b. Inlet louvers, tower fills & fill support, drift eliminators including all supporting structures fastening arrangements & accessories.

c. Screens along with guides embedded in concrete shall be provided at the outlet of cold water channel.

d. Sluice gate with mechanical jack arrangement and guides in each of the cold water outlet channel connection from the cold water basin.

e. Manually operated chain pulley blocks together with the monorails and supporting frames for the handling of screen and gates.

f. Knife-edge gate valve/ sluice valve in each de-sludge connection and also de-sludge piping up to the disposal point at local storm water drain channels.

g. Pipe spools to be embedded in sludge pit walls and terminated with flanged end at suitable distance from outer face of respective wall.

h. Water distribution system consisting of pipes, hangers & pipe supports & anchoring arrangement for all piping coming under the scope of supply.

i. Two (2) nos. (1+1) sludge pumps (submersible type) complete with electric motors, non-return valve, isolation valve, piping support, hangers etc. for cold-water basin drainage. The bidder shall terminate pump discharge pipe work at a distance of 100M from sludge pit.

j. Counter flange, bolts, nuts & gasket for all piping connections in the scope of bidders and also at terminals.

II. ELECTRICALS:

a. Complete electrical equipments as per specification/ details indicated in technical specification (Section – II B) shall be in bidder's scope.

b. The scope of power & control cables & special cables shall be as per Section II B (electrical).

c. Base plate, foundation plate, anchor bolts, sleeves, inserts in concrete work for electrical and mechanical equipment & accessories.

III. C & I

a. Removable type pitot tube at each hot water inlet- piping header to measure the flow (during performance guarantee test only). The pitot tube shall be left with customer after the completion of the test.

b. One number pressure gauge and one number temperature gauge at hot water pipe header at T.P.

c. One number psychrometer

d. Local control panel for sump/ sludge pumps (submersible type)

e. Level switches for sump/ tank level high/normal/low/very low interlocks

f. Actuator for motorized BFV at inlet of hot water pipes

IV. CIVIL:

a. Complete civil (balance) works includes excavation, shoring, dewatering, backfilling, concrete work including shuttering, sand filling, disposal of surplus soil outside plant boundary, formwork including automatic climb form (jump form), laser beam survey instruments, fabrication, galvanizing and erection of steel structures and inserts, finishing anchor bolts, RCC sump/ duct, laying and testing hot water pipe line, water proofing, providing PVC water stops and joint fillers, drainage and other ancillary items connected with cooling towers. All faces of concrete structures and steel structures coming directly in contact with water shall be coated with corrosion resistant coating system as approved. The surfaces that would include are inner face of the hyperbolic shell, raker column faces, inner faces of cold water basin, fill support structures, hot water distribution ducts & channels, cold water channels, etc.

The scope of this work shall consist of, but not limited to, the construction of reinforced concrete double curvature hyperbolic shell, ring beams, foundations (including blasting/ piling (as applicable)), cold water basins with partition walls, hot water ducts, drain sumps, external drain chamber

with associated piping work, cold water channel with sluice gate up to the terminal point as specified elsewhere, hoists and monorails, primary and secondary hot water distribution duct, fill support system including columns and beams, drift eliminators, testing of cold water basin for water tightness, external stairs. Sludge pit for each basin section, all other staircases/ ladders as required, doors and their frames, walkways, platforms, steel fitting, fixture, inserts including fabrication of, hand railing, providing protective measures in concrete and steel materials against effect of water and other chemicals on the completed structure, supply & application of painting at site, etc.

b. The civil construction of the cooling tower shall be in accordance with following technical specifications and the data specification sheets enclosed with this specification –
   i. Earthwork in excavation and backfilling
   ii. Cement concrete (plain & reinforced)
   iii. Masonry and allied work
   iv. Finish to masonry and concrete
   v. Metal doors, windows, ventilators, louvers, etc.
   vi. Roof water proofing, insulation and allied work (as applicable)
   vii. Painting, white washing, polishing, etc. (as applicable)
   viii. Sheet work in roof and siding (as applicable)

c. The technical specifications are of general nature. Only those portions of the specifications which relate to the various works required to be done as per technical requirements as specified in the tender document need to be considered.

d. The cooling tower shell, ring beams, diagonal columns at base supporting ring beams below shell, cold water basin, fill support frame work, hot water distribution duct, cold water channel, louver, etc. shall be cast in-situ RCC construction.

V. The following are also included in bidder's scope:
   a. One set of special tools & tackles required for maintenance of equipment & accessories in the cooling towers.
   b. Various drawings, datasheets, calculations, test reports/ certificates, operation & maintenance manuals including as built drawing etc. as specified & as necessary.
   c. Supply of first fill of lubricants for all equipment under this package including second fill/ replenishments as necessary during & after commissioning till handing over of the plant.
   d. Supply of commissioning spares as on when required basis.
   e. Scope of services shall include but not limited to erection/ testing/ commissioning/ trial run/ performance testing & handing over of cooling

towers. Transportation of equipment, material to site, local clearance, storage at site etc. & supply of all labour including supervision personnel, materials, erection tools & tackles etc. as necessary for expeditious execution of works etc. are also included in bidder's scope. It shall be the responsibility of the bidder to arrange all T & Ps required for execution of complete job including erection & civil works.

VI. Equipment & services to be provided by the purchaser:

a. Supply & erection of incoming hot water piping up to bidder's terminal point
b. Supply & erection of sludge discharge piping beyond the bidder's terminal point, as applicable
c. Cold water outlet channels for cooling tower beyond the bidder's terminal point.
d. For electrical, civil and C & I work refer section C2/ D2, C3 & C4 respectively enclosed herein.

Note: The above provided list is indicative only for the bidder's guideline. For further, detailed scope of work is mentioned in relevant clauses of technical specification. **Any other structure / foundation not mentioned above, but required for completion of the scope of work in total, deemed to have been included in the bidder scope under this contract.** Such work will be executed under this contract by bidder as per the direction of Engineer in charge. If any item of work not available in the rate schedule of this contract, the rate will be fixed in line with clause 2.15.7 of GCC.

Cement & Reinforcement steel for civil works, Structural steel for structural works shall be provided by BHEL free of cost for incorporating them to the permanent works only.

1.2.3. The works to be performed under this contract consist of providing all labour, supervision, material, scaffolding, construction equipment's, tools and plants, temporary works, supplies including POL (petroleum, oil, lubricants, etc.), transportation and all incidental items not shown or specified but reasonably implied or necessary for the proper completion of work in all respects. Testing of all materials, concrete, earthwork other allied works, preparation of bar bending schedules on the basis of construction drawings, preparation of fabrication drawings etc. are included on the rates of items of work. Works shall only be carried out with approved structural fabrication drawings.

1.2.4. The area of work shall be cleared of all vegetation, rubbish and other objectionable Matter and materials removed shall be burnt or otherwise 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.

1.2.5. 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.

1.2.6. The unit rates shall include all material equipment, fixtures, labour construction plant, temporary works and everything whether of permanent or temporary nature necessary for the completion of job in all respects.

1.2.7. The unit rates for various items shall include all the stipulations mentioned in technical specifications for the particular BOQ item and nothing extra over B.O.Q rates shall be payable.

1.2.8. Drawings showing enough details for the construction as per the specification shall be furnished to the contractor in a phased manner.

1.2.9. 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.

1.2.10. Land for labour colony shall be provided by BHEL approximately nearer to site. The contractor to construct labour colony/ hutment as per the technical specification No.PSSR-PMX-CVL LABCOL/02, Rev-01 enclosed along with this tender. The contractor shall provide adequate water arrangement for drinking/washing/bathing with required toilets, drainage system, and electrification etc. in labour colony. Suitable paved area to be provided in the labour colony.

1.2.11.Special arrangements to be made for tackling pandemic – Contractor shall make arrangements for stay of workers within their premises as far as possible and/ or adjacent building and for implementation of STANDARD OPERATING PROTOCOL (SOP) as per government order. The transportation of workers to work place shall be arranged by the contractor in dedicated transport by ensuring social distance. Any person violating the pandemic measures published vide government order time to time will be liable to be proceeded for legal action as per the government order. Following shall be observed in work place:

1.2.11.1. All work places shall have adequate arrangements for temperature screening and provide sanitizers at convenient places.

1.2.11.2. Work places shall have a gap of one hour between shifts and will stagger the lunch breaks of staff, to ensure social distancing.

1.2.11.3. Use of AROGYA SETU will be encouraged for all employees both private and public.

1.2.11.4. Contractor shall sanitize their work place between shifts.

1.2.11.5. Large meetings to be prohibited. Spitting shall be strictly prohibited. Wearing of face cover is compulsory.

1.2.11.6. Government order (state/ center) being issued time to time for protective measures of pandemic shall be complied with strictly until government (state/ center) declares end of pandemic.

1.2.11.7. **Standard operating procedure for social distancing for workplace and offices**

The following measures shall be implemented by contractor for their office and workplaces:

1. All areas in the work premises including the following shall be disinfected completely using user friendly disinfectant mediums:
   a) Entrance gate of work place, office, if any
   b) Cafeteria and canteens, if any
   c) Meeting room, conference halls/ open area available/ verandah/ entrance gate of site, bunkers, porta cabins, buildings, etc.
   d) Equipments and lifts
   e) Washroom, toilet, sink, water points, etc.
   f) Wall/ all other surfaces
2. For workers coming from outside, special transportation facility shall be arranged without any dependency on the public transport system. These vehicles should be allowed to work only with 30-40% passenger capacity.
3. All vehicles and machinery entering the premise should be disinfected by spray mandatorily.
4. Mandatory thermal scanning of everyone entering and exiting the work place to be done.
5. Medical insurance for the workers to be made mandatory.
6. Provision for hand wash & sanitizer preferably with touch free mechanism shall be made at all entry and exit points and common areas. Sufficient quantities of all the items should be available.
7. Work places shall have a gap of one hour between shifts and will stagger the lunch breaks of staff, to ensure social distancing.
8. Large gatherings or meetings of 10 or more people to discouraged. Seating at least 6 feet away from others on job sites and in gatherings, meetings and training sessions.
9. Not more than 2/4 persons (depending on size) will be allowed to travel in lifts or hoists.
10. Use of staircase for climbing should be encourages.
11. There should be strict ban of gutka, tobacco, etc. and spitting should be strictly prohibited.

12. There should be total ban on non-essential visitors at sites.

13. Hospitals/ clinics in the nearby areas, which are authorized to treat pandemic patients, should be identified and list should be available at work place all the times.

VOLUME-IA PART – I CHAPTER – III
FACILITIES & CONSUMABLES IN THE SCOPE OF CONTRACTOR/ BHEL
SCOPE MATRIX

S. NO	DESCRIPTION - PART I	SCOPE TO BE TAKEN CARE BY		REMARKS
		BHEL	BIDDER	
1.3.1.1.	**ESTABLISHMENT**			
1.3.1.1.1.	**FOR CONSTRUCTION PURPOSE:**			
A	Open space for office	Yes		
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's, office / store / canteen consumables		Yes	
E	Canteen facilities for the bidder's staff, supervisors and engineers etc.		Yes	
F	Firefighting equipment's like buckets, extinguishers etc.		Yes	
G	Fencing of storage area, office, canteen etc. of the bidder		Yes	
1.3.1.1.2.	**FOR LIVING PURPOSES OF THE BIDDER**			
A	Open space		Yes	
B	Living accommodation		Yes	
1.3.1.2.	**ELECTRICITY**			
1.3.1.2.1.	Electricity for construction purposes			Free of charges as provided by TSGENCO
1.3.1.2.1.1.	Single point source	Yes		
1.3.1.2.1.2.	Further distribution for the work to be done which include supply of materials and execution		Yes	
1.3.1.2.2.	Electricity for the office, stores, canteen etc. of the bidder which include:		Yes	
1.3.1.2.2.1.	Distribution from single point including supply of materials and service		Yes	
1.3.1.2.2.2.	Supply, installation and connection of material of energy meter including operation and maintenance		Yes	

S. NO	DESCRIPTION - PART I	SCOPE TO BE TAKEN CARE BY		REMARKS
		BHEL	BIDDER	
1.3.1.2.2.3.	Duties and deposits including statutory clearances for the above		Yes	
1.3.1.2.2.4.	Living facilities for office use including charges		Yes	
1.3.1.2.2.5.	Demobilization of the facilities after completion of works		Yes	
1.3.1.2.3.	Electricity for living accommodation of the bidder's staff, engineers, supervisors etc. on the above lines.(in case BHEL provides this facility, the scope should be given without ambiguity)		Yes	
1.3.1.3.	**WATER SUPPLY**			
1.3.1.3.1.	For construction purposes:	Yes		Free of charges as provided by TSGENCO
1.3.1.3.1.1.	Making the water available at single point	Yes		
1.3.1.3.1.2.	Further distribution as per the requirement of work including supply of materials and execution		Yes	
1.3.1.3.2.	Water supply for bidder's office, stores, canteen etc.			
1.3.1.3.2.1.	Making the water available at single point		Yes	
1.3.1.3.2.2.	Further distribution as per the requirement of work including supply of materials and execution		Yes	
1.3.1.4.	**LIGHTING**			
1.3.1.4.1.	For construction work (supply of all the necessary materials) At office storage area At the preassembly area At the construction site / area		Yes	
1.3.1.4.2.	For construction work (Execution of the lighting work / arrangements) At office storage area At the preassembly area At the construction site /area		Yes	
1.3.1.5.	**COMMUNICATION FACILITIES FOR SITE OPERATIONS OF THE BIDDER**			
1.3.1.5.1.	Telephone, Fax, internet, intranet, email etc.		Yes	

S.NO	DESCRIPTION - PART II	SCOPE TO BE TAKEN CARE BY		REMARKS
		BHEL	BIDDER	
1.3.2.	**CONSTRUCTION FACILITIES**			
1.3.2.1.	**ENGINEERING WORKS FOR CONSTRUCTION**			
1.3.2.1.1.	Providing the construction drawings for all the equipment covered under this scope	Yes		
1.3.2.1.2.	Drawings for construction methods		Yes	In consultation with BHEL
1.3.2.1.3.	As-built drawings – wherever deviations observed and executed and also based on the decisions taken at site- example – routing of small bore pipes	Yes	Yes	”
1.3.2.1.4.	Shipping lists etc. for reference and planning the activities	Yes	Yes	”
1.3.2.1.5.	Preparation of site construction schedules and other input requirements		Yes	In consultation with BHEL, As per requirement of BHEL targets
1.3.2.1.6.	Review of performance (Form-14) and revision of site construction schedules in order to achieve the end dates and other commitments		Yes	
1.3.2.1.7.	Weekly construction schedules based on SNo.1.3.2.1.5		Yes	
1.3.2.1.8.	Daily construction / work plan based on S.No.1.3.2.1.7		Yes	For daily monitoring meeting at site
1.3.2.1.9.	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 two months.		Yes	
1.3.2.1.10.	Preparation of preassembly bay		Yes	
1.3.2.1.11.	Laying of racks for gantry crane if provided by BHEL or brought by the contractor / bidder himself			Not applicable

1.3.3. **OPEN SPACE:**

Availability of land within plant boundary is very limited and the contractor has to plan and use the existing land considering the use of land by other Civil

/mechanical/ electrical contractors and the storage of plant machineries and materials. The existing land shall be shared by all erections agencies. Land will be allocated with certain time frame and to the extent available/ considered necessary, and will be reviewed by BHEL depending upon the area availability. Area within plant premises for fabrication, batching plant, office, storage area etc. for construction purpose shall be provided as per availability free of cost. The contractor will be responsible for handing back all lands, as handed over to him by BHEL.

1.3.4. **ELECTRICITY:**

1.3.4.1. Construction power will be provided to the contractor at one single point within the plant area by BHEL on free of cost basis as per the as provided by TSGENCO. The contractor to Provide necessary meter for measuring the power consumption. The contractor shall make his own arrangement for further distribution with necessary isolator/LCB etc.

1.3.4.2. Necessary "Capacitor Banks" to improve the Power factor to a minimum of 0.9 shall be provided by the contractor at his cost. Penalty if any levied by customer on this account will be recovered from contractor's bills.

1.3.4.3. Any duty, deposit involved in getting the Electricity shall be borne by the bidder. As regards contractor's office shed also all such expenditure shall be borne by the contractor.

1.3.4.4. Provision for distribution of electrical power from the given single central common point to the required places with proper distribution boards, approved cables and cable laying including supply of all materials like cables, switch boards, pipes etc., observing the safety rules laid down by electrical authority of the State / BHEL / their customer with appropriate statutory requirements shall be the responsibility of the tenderer / contractor.

1.3.4.5. BHEL is not responsible for any loss or damage to the contractor's equipment as a result of variations in voltage / frequency or interruptions in power supply.

1.3.4.6. Contractor has to make their own arrangements for electricity requirement for labour colony at their cost.

1.3.4.7. As there are bound to be interruptions in regular power supply, power cut/ load shedding in any construction sites, contractor should make his own arrangement for alternative source of power supply through deployment of adequate number of DG sets at their cost during the power breakdown / failure to get urgent and important work to go on without interruptions. No separate payment shall be made for this contingency.

1.3.5. **WATER:**

1.3.5.1. Construction Water at single point will be provided by BHEL as provided by TSGENCO and further distribution is in the scope of bidder. The required pumps & accessories, pipes for drawing water from the given point and further

distribution will be arranged by the contractor at their cost to go on without interruptions.

1.3.5.2. In case of non-availability of water, the contractor shall make his own arrangements of water suitable for construction purpose to have un-interrupted work. No separate payment shall be made for any contingency arrangement made by contractor, due to delay/ failure for providing water supply.

1.3.6. **MATERIAL SUPPLY:**

Supply / providing aggregate, river sand and all other materials required for the work are in the scope of the contractor. **BHEL shall provide cement & reinforcement steel for civil works, structural steel for fabrication works only for incorporation in the permanent work AS FREE SUPPLY**.

- Regarding supply of cement, the cement shall be provided normally in bulkers and shall be unloaded in the silos (2 Nos minimum 100MT each per 30 Cum batching plant and 2 Nos minimum 100MT each per 60 Cum batching plant) to be installed by the bidder nearer to their batching plants. This is only minimum requirement and the No. of cement silos shall be increased based on the site requirement. On advance request of the bidder, the cement shall be supplied in Bags for other than RCC works like masonry, flooring works etc. Advance request for supply of cement in bags shall be minimum two months.
- The steel material will be issued from BHEL stores, within the plant premises. Collection and transporting to the place of work is in contractor's scope without any extra cost to BHEL. The steel will be issued to the agency in standard lengths. In some instances, for 8mm, 10mm &12mm dia. reinforcement steel will be supplied in coil form. No extra claims will be entertained against issue of Non-standard lengths of steel and de coiling of 8mm, 10mm &12mm dia. steel.
- Bidder to note that steel materials required for Embedment's, inserts, MS Grating, Galvanized Grating, GI Handrail, Stainless Steel Handrail, SS Sheets for Bunker liner, Stop Lock Gate, Stationery Screen, fasteners like MS/HT/HSFG bolts/nuts, lock nuts, washers and foundation bolts other than those supplied by BHEL, shall be supplied by the bidder. However, Bidder shall use the scrap materials available with BHEL or with the respective bidders, for their use in the permanent works as embedment/inserts etc. after necessary store issue formalities, if taken from BHEL and shall be accounted for monthly reconciliation, if it belongs to the bidder's scrap materials.
- If any matching sections of steel are not available with BHEL, contractor may arrange these sections from Customer approved agencies only on certification of BHEL and the same shall be paid against relevant BOQ item in the price bid.

1.3.6.1. **AGGREGATES:**

Aggregates shall be natural or crushed gravel or crushed rock and free from deleterious materials. It shall comply with the requirements of IS-383. All fine and coarse aggregate shall be tested for susceptibility to alkali silicate reaction in a laboratory approved by the engineer in-charge.

- Coarse aggregate
  Aggregate of sizes ranging between 4.75mm and 150m will be termed as coarse aggregate. Only coarse aggregate from approved quarries and conforming to IS:383 will be allowed to be used on the works. Aggregates shall be washed to make it free from deleterious materials, if necessary.

  The grading of coarse aggregates by sieve analysis shall be as per IS:383.

- Fine aggregate
  Aggregate smaller than 4.75mm and within the grading limits and other requirements set in IS:383 will be 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 on works.

  In certain cases, there may be two types of sand, one very fine sand and the other very coarse. In such cases, the two types shall be combined to meet the requirements of a particular zone of IS:383. In most cases, the preferred zone is Zone-II. Bidder shall supply/ provide only river sand for this scope of work.

1.3.7. **CONSUMABLE**

All consumables, like gas, electrodes, chemicals, lubricants etc. required for the scope of work, shall be arranged by the contractor at his cost unless otherwise specifically mentioned in the contract. In the event of failure of contractor to bring necessary and sufficient consumables, BHEL may arrange for the same at the risk and cost of the contractor. The entire cost towards this along-with overhead shall be paid by the contractor or deducted from the contractor's bills.

1.3.8. **LIGHTING FACILITY:**

Adequate lighting facilities such as flood lamps, hand lamps0 and area lighting shall be arranged by the contractor at the site of construction, and contractor's material storage area etc. at his cost.

1.3.9. **CONTRACTOR'S OBLIGATION ON COMPLETION**:

On completion of work, all the temporary buildings, structures, pipe lines, cables etc. shall be dismantled and leveled and debris shall be removed as per instructions of BHEL by the contractor at his cost. In the event of his failure to do so, the expenditure towards clearance of the same will be

recovered from the contractor. The decision of BHEL Engineer in this regard is final.

1.3.10. **BLASTING**

Bidder should produce documentary evidence of valid blasting license for Telangana State (or) should produce documents for having tie-up with agency who is possessing valid blasting license for Telangana state within 30 days from issue of LOI.

For details on blasting, refer enclosed bill of quantity (rate schedule) & Volume-IA Part-II, Technical specification.

1.3.11. **DEWATERING**

Contractor shall ensure at all times that his work area & approach/ access roads are free from accumulation of water, so that the materials are safe and the erection/ progress schedule are not affected. No separate claim in this regard shall be admitted by BHEL. No separate payments for dewatering of subsoil, surface water or catchments water, if required, at any time during execution of the work including monsoon period shall be considered by BHEL.

1.3.12. **BID DRAWINGS**

Drawings enclosed is only tentative & for information purpose and this may get revised during execution.

VOLUME-IA PART – I CHAPTER – IV T&Ps AND MMEs TO BE DEPLOYED BY CONTRACTOR

1.4.1. All the tools and plants required for satisfactory completion of the work have to be arranged by the contractor.

1.4.2. The contractor is required to arrange the following suggestive **minimum** Major T&Ps and minimum other T&Ps for the satisfactory completion of the work.

Sr No	Description of Tools & Plants	Mobilizing time from the date of start of work
	Major T&P	
B1	1 No. Poclain CK90 excavator	1 no. within 20 days, depending up on the requirement.
B2.1	1 no. automatic concrete batching plant with printing facility (60 Cum/Hr) – and DG backup. With minimum 2 Nos of silo (100MT each) per batching plant.	1 nos to be commissioned Within 30 days
B2.2	1 no. automatic concrete batching plant with printing facility (30 Cum/Hr) – and DG backup. With minimum 2 Nos of silo (100MT each) per batching plant.	1 nos to be commissioned Within 60 days
B3	Suitable capacity tyre mounted crane – 1 no.	As per requirement at site
B4	Tower crane of suitable capacity for height of approx. 200m and bottom radius 75m along with operator and necessary spares – 1 no.	Within 30days from commencement of work at site
B4A	Scissor lift of suitable capacity for erection of fill structures.	As per requirement at site
B5	Jump form for shell concreting along with all accessories e.g. required no. of jacks (including spare jacks), power packs, ropes, safety accessories, etc. all complete required for smooth operation of jump form – 1 set.	As per requirement at site
B6	Suitable passenger lift cabin for carrying (min 8 passengers) along with all accessories – 1no.	To be arranged at site before commencement of work of shell

Sr No	Description of Tools & Plants	Mobilizing time from the date of start of work
B7	1 nos. Concrete Boom Placer of 36m boom length (as applicable) additional 1 concrete pump as stand by (60 cum/ hr min capacity & lift 90M)/.	Boom placer 1 No within 15 days/ Concrete pump as per requirement.
B8	5 no. transit mixer (5/6 M3 capacity) with standby 1 no.	3 no within 15 days. Balance as per site requirement.
	Other T&Ps	
B9	1 No. JCB	As per site requirement.
B10	2 nos. dumper (Min 15 cum each)	As per site requirement.
B11	1 nos. diesel Mixer machine of 0.5 cum capacity	As per requirement at site
B12	1 nos. self-priming dewatering pump 5 HP (diesel)	Within 20 days.
B13	2 nos. self-priming dewatering pump 10 HP (electric)	Within 10 days
B14	3 nos. curing pump – 1.5 /2 HP (pump for curing at heights)	1 no. within 20 days 2 nos within 45 days.
B15	3 nos. reinforcement bending machine	As per site requirement.
B16	1 no. Vibromax (earth compactor)	As per site requirement.
B17	2 nos. reinforcement cutting machine	As per site requirement.
B18	Welding rectifiers – 2nos for piping erection	As per requirement at site
B19	8 sets of raker column steel shuttering	As per requirement at site
B20	MS scaffolding pipe / ACROW SPAN	As per requirement at site
B21	Welding machine (submerged arc) – 2 nos	As per requirement at site
B22	1 nos. power driven earth rammer (Roller Type 1/2 T)	As per requirement at site
B23	Civil laboratory equipment's as per list in Sl. 4.4.2 with temporary building one AC lab size 4.5mtrx6mtr and 1 non AC lab 4.5 mtrx4.5 mtr.	Within 30 days.
B24	Optical/laser plumb – 3 nos	Before start of shell concreting
B25	2 no total station with adequate arrangement for Surveyors.	1 no. Within 15 days. and balance progressively as per requirement

Sr No	Description of Tools & Plants	Mobilizing time from the date of start of work
B26	2 no theodolite 1 second accuracy	1 no. within 15 days. and balance progressively as per requirement
B27	3 no's auto level & staff + 2 no's as required	2 nos. Within 15 days. And balance as per requirement.
B28	100 no's concrete cube moulds	50 nos within 30 days and balance progressively as per requirement
B29	Adequate no. of small trucks 2T/5T for shifting of reinforcement/cement/shuttering etc. within site	As per requirement at site
B30	1 nos. drinking water tank – 5000 lit.	As per requirement at site
B31	2 nos. mobile toilet blocks for labour use.	As per requirement at site
B32	1 nos. truck mounted 125 KVA DG set	As per requirement at site
B33	Construction power cable	As per requirement at site
B34	Construction water Pipeline	As per requirement at site
B35	1 nos ultra-sonography testing machine	As per requirement at site
B36	Concrete vibrator with adequate needle (Minimum 10 nos diesel/electric)	6Nos (at least 3nos. diesel driven) within 45 Days. Balance as per site requirement.
B37	Portable fire extinguishers as below: Soda acid – 10 sets. Dry chemical powder – 10 sets CO2 – 10 sets. Water & sand bucket (4 buckets in one stand) – 10 sets. Fire hose with nozzle (50 M length) – 5 sets.	25% within 30 days and balance progressively within 90 days.
B38	1 no. compression testing machine (200 T cap)	1 Nos. within 30 days
B39	2 Nos. Multi stage high lift water pump (for curing) (lifting height 210 metres). One shall be working and other shall be stand by.	Before of start of NDCT shell
B40	Power winch -2.5 T – 1 nos. for Internal / External Finishing as applicable	As per requirement at site
B41	Walky Talky – 3 Nos	As per requirement at site

Note:

1. T&P shown in the above mentioned list and the mobilization schedule is tentative requirement considering parallel working. However, mobilization schedule modification as well as no. of T&Ps as mutually agreed at site for major T&Ps, have to be adhered to. Numbers/ time of requirement will be reviewed time to time at site and contractor will provide required T&P/ equipment's to ensure completion of entire work within schedule/target date of completion without any additional financial implication to BHEL. Vendor shall give advance intimation & certification regarding capacity etc. prior to dispatch of heavy equipment's. Also on completion of the respective activity, demobilization of T&P in total or in part can be done with the due approval of engineer in charge. Retaining of the T&P's during the contract period will be mutually agreed in line with construction requirement.
2. All T&P and all IMTEs, which are required for successful and timely execution of the work covered within the scope of this tender, shall be arranged and provided by the contractor at his own cost in working condition.
3. In the event of contractor failing to arrange the required tools, plants, machineries, equipment, material or non-availability of the same owing to breakdown, BHEL will make alternative arrangement at the risk and cost of the contractor.

   Case 1: BHEL provides its own Capital T&P

   In case the BHEL provides any T&P which is owned by BHEL, hire charges (as per BHEL norms) will be recovered from the contractor as per the prevailing BHEL corporate hire charges. In case, the T&P is specifically listed in "T&Ps to be deployed by Contractor", "Hire charges applicable to outside agencies other than contractors working for BHEL" will apply. If not listed, "hire charges applicable to contractor working for BHEL" will apply. The hire charges of Capital tools & plants are exclusive of operating expenses e.g. operator, fuel & consumables and the same shall be arranged by the contractor at his cost.

   Case 2: In all cases other than that specified in case 1 above, actual expenses incurred by BHEL along with applicable overheads will be back-charges to the contractor.
4. In the event of need of change of type of any of major T&Ps, approval shall be taken from BHEL Engineer in-charge prior to mobilization. The decision of Number of T&P required due to replacing the enlisted T&P as per above table, shall be taken after analyzing the production capacity and suitability of both the T&Ps.
5. Clause no. 1.6.1.1 of this specification may please be referred for date of start of work.

1.4.3. In addition to the above, any other tools and plants required for execution of the above work are in contractor's scope.

1.4.4. The Bidder shall establish laboratory arrangements or get the materials tested through approved national accredited laboratory and submit the reports for approval of BHEL/ Customer.

1.4.4.1. The laboratory must have qualified technicians to carry out all tests and must be adequately equipped to ensure that all necessary testing work can carried out in compliance with the standards.

1.4.4.2. Field and laboratory testing procedures for materials follow Indian standard specifications with necessary equipment's like as given in table below:

CONCRETE TESTING EQUIPMENT

S NO	NAME OF TEST	NAME OF EQUIPMENT	SIZE OF EQUIPMENT	IS REF.
1	Initial & final setting time, Consistency of cement	Vicat Apparatus with desk pot	Standard	IS 5513
2	Shrinkage of cement, Auto Clave Test	Le Chatelier's appratus Auto Clave Equipment	Standard	IS 5514
3	Abrasion value test	Los Angles Abrasion testing machine	Standard	IS 2386
4	Aggregate Impact value test	Aggregate Impact value testing machine with blow counter	Standard	IS 9377
5	Aggregate crushing value test	Crushing value apparatus	Standard	IS 2386
6	Flakiness index	Thickness gauge for measuring flakiness index	Standard	IS 2386
7	Elongation Index	Elongation gauge	Standard	IS 2386
8	Bulk density, voids and bulking apparatus	Measuring cylinders	3, 5,10 & 15 liters cylinders	
9	Workability of concrete	Slump cone	Standard, at least 04 no's	IS 456
10	Specific gravity of aggregates	Pycnometer	Standard, at least 02 no's	IS 383
11	Cement mortar cube vibrating	Motorized vibration machine for cement testing	Standard	IS 4031

12	Course aggregate Sieve analysis (Concrete & Road Works)	Sieve set	450mm dia GI Frames Size: 125 mm, 90 mm, 75 mm, 63 mm, 53 mm, 40 mm, 20 mm, 16 mm, 12.5 mm, 10 mm, 4.75 mm, Pan and cover	IS 383
13	Fine aggregate sieve analysis	Sieve set	200 mm dia Brass sieves; Size 4.75 mm, 2.36 mm, 1.18 mm 600 micron, 300 micron, 150 micron, 75 micron, 75 micron, Pan and cover	IS 383
14	Sieve Shaker	Motorized Sieve shaker	Mfg. Catalogue	
15	Silt content check	Sand silt content beaker	Standard	

1.4.5. Contractor shall have at all times experienced operators and technicians for routine and breakdown maintenance of the equipment. Any delay in rectification of defects will warrant BHEL rectifying the defect and charging the cost to the contractor.

1.4.6. The area and infrastructure development of the work area are to be carried out by the customer. However, in construction projects of this magnitude all the areas/ approaches might not be ready. In such cases consolidation of ground and arrangement of sleepers/ sand bag filling etc. for safe operation/ movement of equipment including cranes/ trailers etc. shall be the responsibility of the contractor at his cost. No compensation on this account shall be payable.

1.4.7. In case the contractor fails to provide any T&P which is in the scope of contractor and if BHEL provides such T&P available with BHEL, hire charges prevailing (as per BHEL norms) as on that day will be recovered from the contractor as per the prevailing BHEL Corporate Crane hire charges (may vary from time to time). Corresponding pages of Corporate Crane hire charges are enclosed in Part II of Technical Conditions of Contract. This may get revised further as per the BHEL corporate guidelines. However, prevailing rates as on date of execution may be applicable.

1.4.8. Crane operators deployed by the contractor shall be tested by BHEL before they are allowed to operate the cranes.

1.4.9. In case, cement is issued through bulkers being supplied from manufacturer/ stockiest, the same shall be emptied in cement silos of batching plant and necessary assistance shall be provided by contractor. Contractor to note that batching plant being established at site shall have cement silos of 100 MT capacities each as mentioned in clause 1.4.2.- list of Tools & Plants to be deployed by the contractor.

VOLUME-IA PART – I CHAPTER – V
T&Ps AND MMEs TO BE DEPLOYED BY BHEL ON SHARING BASIS

1.5.1. BHEL will not provide any T & Ps for this scope of work.

1.5.2. All the tools and plants required for execution of the above work are in contractor's scope.

1.5.3. In case if the contractor fails to provide T&P and other equipment's, BHEL will arrange for the same and the cost will be recovered from the contractor's bill with BHEL overheads, as applicable from time to time which may vary during contract period.

VOLUME-IA PART – I CHAPTER-VI

TIME SCHEDULE

1.6.1. **TIME SCHEDULE**

1.6.1.1. The commencement of work at site shall be mutually agreed date between bidder and BHEL to start the work.

1.6.1.2. The entire works of the cooling towers including green belt area (as applicable) as detailed in the Tender Specification shall be completed within 25 (Twenty-Five) months from the date of commencement of work.

1.6.1.2.1. Readiness for unit synchronization (half basin): 19 months

1.6.1.2.2. Final bill & contract closure: 25 months

1.6.1.3. During the total period of contract, the contractor has to carry out the activities in a phased manner as required by BHEL and the program of milestone events.

1.6.1.4. The contractor is required to refer Form 15 in Volume 1- BOOK 2 for all the instructions to be taken immediately after receipt of LOI.

1.6.2. **MOBILISATION**

The Contractor has to subsequently augment his resources in such a manner to achieve the COMPLETION SCHEDULES:

The above time allowed for completion of work including Sundays and Holidays is from the date of commencement of work. Detailed program to be prepared by the tenderer taking in to consideration of the COMPLETION SCHEDULES /site decision on drawings flow (latest) and submitted for BHEL's approval.

1.6.3. 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.

1.6.4. In case the project is to be advanced, the civil works in the scope of the contractor is to be advanced to meet the project requirement. No extra payment whatsoever shall be paid on this account.

1.6.5. **SUBMISSION OF L3 SCHEDULE**

The contractor shall submit a detailed area/ structure wise L3 schedule within 7 days in consultation with BHEL based on the tentative schedule provided as per the clause1. 6.7. The detailed L3 schedule shall be approved by BHEL and same shall be implemented. Bidder shall submit L3 schedule in MS Projects to meet the agreed project schedule covering various milestone activities and their split up details such as construction,

procurement of materials, fabrication & erection activities. This schedule shall also clearly indicate the interface facilities/inputs to be provided by BHEL/Customer and the dates by which such facilities/inputs are required. The schedule shall be acceptable to BHEL for meeting their mile stone targets/schedule.

1.6.6. **GUARANTEE PERIOD**

The Guarantee period shall be as mentioned below:

1.6.6.1. As stipulated in General conditions of contract Clause no. 2.24 "PERFORMANCE GUARANTEE FOR WORKMANSHIP"

or

1.6.6.2. 18 calendar months from the date of completion of supplies

or

1.6.6.3. 12 calendar months from the date of satisfactory commissioning of the package,

whichever is later.

Seller/ contractor's liability in respect of any complaints, defects and claims shall not be limited to supply and installation of replaced parts free of charge, or repair of defective parts to the extent that such replacements are attributable to or arise from faulty workmanship, material or design, in the manufacture, of the stores but at the option of purchaser, to the payment of the value, expenditure and damages as mentioned hereafter, provided defects on being discovered are brought to the notice of the seller/ contractor within a period of three (3) months from the date of expiry of the guarantee period as per the specification.

1.6.7. **CIVIL WORKS SCHEDULE FOR NDCT 4**

The schedule for civil works is as given below.

Sl. No	Area of work	Completion from the date of commencement of civil work
1	Initial site mobilization	Within 1 Month
2	Tower crane erection	Progressively by 2nd Month
3	Basin floor	Progressively by 3rd month
4	Basin wall & pedestals	Progressively by 4th month
5	Completion of Raker column	Progressively by 5th month
6	Grillage structure	Progressively by 10th month
7	Completion of precast beams	Progressively by 10th month
8	RCC for Cold water channel	Progressively by 14th month
9	RCC hot water duct	Progressively by 14th month
10	RCC shell	Progressively up to 15th month
11	Completion of fills	Progressively by 16th month

Sl. No	Area of work	Completion from the date of commencement of civil work
12	Completion of hot water inlet pipes	Progressively by 16th month
13	All electrical works, staircase, internal painting, cage ladder erection	Progressively by 17th month
14	Readiness for unit sync (readiness of half basin)	Progressively by 19th month
15	Readiness of complete cooling tower including inspection, testing	Progressively by 23rd months
16	Entire finishing and handing over, final bill & reconciliation	Progressively by 25th month
17	PG test	As per BHEL readiness and instruction

PENALTY FOR INTERMEDIATE MILESTONES FOR COOLING TOWER (NDCT-4)

S No	Description	Completion month from the contractual date of start of the work	Intermediate Milestone
NDCT 4 of Unit 4			
1	Completion of Raker column	5th Month	M1
2	Completion of RCC shell	15th month	M2

1.6.7.1. M1 and M2 shall be intermediate milestones for this work for each NDCT. In case delay in achieving M1 milestone the penalty shall be levied on the bidder. In case delay in achieving each 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. Incase delay in achieving each M2 milestone is solely attributable to the contractor, 0.5% per week of executable contract value** limited to Maximum 3.0% of executable contract value will be withheld.

1.6.7.2. 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.

1.6.7.3. Amount required to be withheld on account of slippage of identified intermediate milestone shall be withheld out of respective milestone payment and balance amount shall be withheld at 10% of RA bill amount from subsequent RA bills.

1.6.7.4. 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 as per GCC. Withheld amount, if any due to slippage of intermediate milestones shall be adjusted against LD or released as the case may be.

1.6.7.5. 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.

Note: **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.

1.6.8. **RECORDS TO BE MAINTAINED AT SITE:**

1.6.8.1. Record of Quantity of FREE/Chargeable items issued by BHEL must be maintained during contract execution. Also reconciliation statement to be prepared at regular intervals.

1.6.8.2. The under mentioned Records/ Log-books/ Registers applicable to be maintained.

1.6.8.2.1. Hindrance Register.

1.6.8.2.2. Site Order Book.

1.6.8.2.3. Test Check of measurements.

1.6.8.2.4. Cement Supply and Consumption Daily Register

1.6.8.2.5. Records of Test reports of Field tests.

1.6.8.2.6. Records of manufacture's test certificates.

1.6.8.2.7. Records of disposal of scraps generated during and after the work completion.

1.6.9. The above schedule is tentative. In case the project is to be advanced, the civil works in the scope of the contractor is to be advanced to meet the project requirement. No extra payment whatsoever shall be paid on this account.

The above completion schedule against each structure/ building is for entire completion and handing over the structure/ Building to BHEL. The foundations, pedestals, floors, etc., required for the mechanical equipment erection/ structural erection shall be handed over to BHEL progressively within the scheduled period given in the above table, as per the BHEL site requirement.

1.6.10. The above time allowed for completion of work including Sundays and Holidays is from the date of commencement of work. Detailed program to be prepared by the bidder taking in to consideration of the COMPLETION SCHEDULES/ site decision on drawings flow (latest) and submitted for BHEL's approval.

1.6.11. In order to meet the 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 Engineer.

1.6.12. The bidder must submit a detail schedule (area wise) for completion of work to meet civil work schedule given in Clause 1.6.7 within 15 days from the date of issue of LOI.

1.6.13. The major activities as mentioned against the work schedule given in clause No.1.6.7 are to be indicated in detailed schedule which will be prepared by the bidder:

VOLUME-IA PART – I CHAPTER-VII
TERMS OF PAYMENT

1.7.1. **SECURED ADVANCE**

Not applicable

1.7.2. **ADVANCE FOR MOBILIZATION**

1.7.2.1. Interest bearing advance for mobilization, limited to 5% of the contract value will be paid against submission of bank guarantee of at least 110% of the advance valid for the contract period, which will be recovered from the first running bill onwards. The advance for mobilization shall be paid as under.

1.7.2.2. 2% of contract value after receipt of initial security deposit and additional security deposit as applicable (if any), consortium SD (if applicable) as per relevant clauses in the GCC/ TCC along with unqualified acceptance of detailed letter of intent.

1.7.2.3. 1.5% of the contract value on completion of site mobilization of machinery & T&Ps as given below and on certification by site in-charge for compliance (subjected to compliance of clause no. 1.7.2.2):

1. JCB – 1 no.
2. Poclain CK90 excavator – 1 no.
3. Batching plant – 30 cum/ hr capacity – 1 no. with 2 nos silo (100MT each)

1.7.2.4. 1.5% of contract value on completion of site mobilization of machinery and T&Ps as given below in addition to the above, and on certification by site in-charge for compliance:

1. Transit mixer – 2 nos
2. Concrete pump – 1 no.

1.7.3. **INTERIM PAYMENT**

1.7.3.1. Interim bills in the form of monthly running bills prepared by the contractor in soft as well as Hard copies shall be based on the quantities executed and measured.

1.7.3.2. 90% item rate shall be released after completion of works certification by Engineer in charge.

1.7.3.3. 5% of the item rate shall be released after submission of the quality check formats as per the quality plan for the quantum of work billed and duly certified by engineer.

1.7.3.4. Further, 5% can only be released after successful completion of commissioning and handing over of the cooling tower.

1.7.3.5. All admissible deductions shall be made from the above 90% value.

1.7.3.6. Retention amount shall be as per Clause no. 2.22 of General Conditions of Contract (GCC).

1.7.3.7. BHEL Site Engineer, at discretion, may operate the part rate of the items in line with GCC clause no. 2.23.1 (v). Payment for supply portion (subjected to approval of Engineer In-Charge) shall be made only after receipt of material at site.

1.7.4. **ROYALTY/ SEIGNIORAGE CHARGES**

Royalty/ seigniorage charges (if any) for excavation inside plant premises as applicable as per Govt. of Telangana shall be reimbursable to the bidder by BHEL for the quantum of earth work done on submission of necessary proof of payments as required by M/s TSGENCO for reimbursement.

1.7.5. **METHOD OF MEASUREMENT**

Mode of measurement shall be as per relevant clauses of the relevant IS 1200 in conjunction of IS code 3385 shall be adopted. In case the same is also not available, the standard procedure adopted in CPWD shall be adopted. In case the same is also not available in CPWD, the measurement of the work done will be based on the mutual agreement between BHEL and contractor. In all the above cases, the interpretation of BHEL will be final and binding to the contractor. Measurement guidelines as a ready reference is also available in the technical specification.

1.7.6. **NO CLAIM WHAT SO EVER MAY BE, WILL BE ENTERTAINED UNDER THIS CONTRACT, AFTER DULY SIGNING THE FINAL BILL ALONG WITH MEASUREMENT BOOKS AND ACCEPTED BY BHEL.**

VOLUME-IA PART – I CHAPTER-VIII
TAXES AND DUTIES

1.8.1. **Goods and service Tax (GST) & Cess**

1.8.1.1. The successful bidder shall furnish proof of GST registration with GSTN Portal in the State in which the Project is being executed, covering the services under this contract. Registration should also bear endorsement for the premises from where the billing shall be done by the successful bidder on BHEL for this project/ work.

1.8.1.2. Contractor's price/rates shall be exclusive of GST & Cess (if applicable) (herein after termed as GST). Contractor shall submit to BHEL the GST compliant tax invoice/debit note/revised tax invoice on the basis of which BHEL will claim the input tax credit in its return. Since this is a works contract, the applicable rate shall be @ 18% GST, as applicable presently.

1.8.1.3. Bidder shall note that the GST Tax Invoice complying with GST Invoice Rules wherein the 'Bill To' details will as below:

BHEL GSTN - 36AAACB4146P1ZG
NAME - BHEL Site Office
ADDRESS - Yadadri Thermal Power Station, 5X800 MW (Coal based), Veerlapalem village, Dameracherla Mandal, Nalgonda District, Telangana State

1.8.1.4. GST charged in the tax invoice/debit note/revised tax invoice by the contractor shall be released separately to the contractor only after contractor files the outward supply details in GSTR-1 on GSTN portal and input tax credit of such invoice is matched with corresponding details of outward supply of the contractor and has paid the GST at the time of filing the monthly return.

1.8.1.5. In case BHEL has to incur any liability (like interest / penalty etc.) due to denial/reversal / delay of input tax credit in respect of the invoice submitted by the contractor, for the reasons attributable to the contractor, the same shall be recovered from the contractor.

1.8.1.6. Further, In case BHEL is deprived of the Input tax credit due to any reason attributable to contractor, the same shall not be paid or Recovered if already paid to the contractor.

1.8.1.7. Tax invoice/debit Note/revised tax invoice shall contain all such particulars as prescribed in GST law and comply to the timelines for issue of the same. Invoices shall be submitted on time to the concerned BHEL Engineer In Charge.

1.8.1.8. TDS under GST (if/ as & when applicable) shall be deducted at prevailing rates on gross invoice value from the running bills.

1.8.1.9. E-way bills / Transit passes / Road Permits, if required for materials / T&P etc., bought into the project site is to be arranged by the Contractor only.

1.8.1.10. BHEL shall not reimburse any amounts towards any interest / penalty etc., incurred by contractor. Any additional claim at a later date due to issues such as wrong rates / wrong classification by contractor shall not be paid by BHEL.

1.8.2. **All taxes and duty other than GST & Cess**

The contractor shall pay all (except the specific exclusion viz GST & Cess) taxes, fees, license charges, deposits, duties, tools, royalty, commissions, Stamp Duties, or other charges / levies, which may be levied on the input goods & services consumed and output goods & services delivered in course of his operations in executing the contract and the same shall not be reimbursed by BHEL. In case BHEL is forced to pay any of such taxes, BHEL shall have the right to recover the same from his bills or otherwise as deemed fit.

1.8.3. **Statutory Variations**

Statutory variations are applicable under the GST Acts, against production of proof. The changes implemented by the Central / State Government during the tenure of the contract viz. increase / decrease in the rate of taxes, applicability, etc. and its impact on upward revision / downward revision are to be suitably paid/ adjusted from the date of respective variation. The bidder shall give the benefit of downward revision in favour of BHEL. No other variations shall be allowed during the tenure of the contract.

1.8.4. **New Taxes/Levies** –

In case Government imposes any new levy / tax after submission of bid during the tenure of the contract, BHEL shall reimburse the same at actual on submission of documentary proof of payment subject to the satisfaction of BHEL that such new levy / tax is applicable to this contract.

1.8.5. **Direct Tax**

BHEL shall not be liable towards Income Tax of whatever nature including variations thereof arising out of this contract as well as tax liability of the bidder and their personnel. Deduction of tax at source at the prevailing rates shall be effected by BHEL before release of payment as a statutory obligation, unless exemption certificate is produced by the bidder. TDS certificate will be issued by BHEL as per the provisions of Income Tax Act.

VOLUME-IA PART –I CHAPTER -IX
BILL OF QUANTITY

1.9.1. Refer Volume-II, Price Bid.

VOLUME-IA PART –I CHAPTER -X GENERAL

The scope of the work will comprise of but not limited to the following: (All the works mentioned hereunder shall be carried out within the accepted rate unless otherwise specified.)

1.10.1. Bidders are requested to furnish the following at PSSR-HQ

i. Security Deposit.
ii. Unqualified Acceptance for Detailed LOI / Work Order.
iii. Rs.100/- Stamp Paper for preparation of Contract Agreement.

1.10.2. Bidders are requested to furnish the proof of documents for the following at the respective PSSR- Site

i. PF Regn No.
ii. Labour License No.
iii. Workmen Insurance Policy No.

1.10.3. **In addition to the clause 2.8 of General Conditions of Contract (Volume-1C of Book-II) the contractor shall comply with the following.**

1.10.3.1. **BOCW Act & BOCW Welfare Cess Act**

1.10.3.1.1. The Contractor should Register their Establishment under BOCW Act 1996 read with rules 1998 by submitting Form I (Application for Registration of Establishment) and Form IV (Notice Of Commencement / Completion of Building other Construction Work) to the respective Labour Authorities i.e.,

a) Assistant Labour Commissioner (Central) in respect of the project premises which is under the purview of Central Govt.–NTPC, NTPL etc.

b) Appropriate State authorities in respect of the project premises which is under the purview of State Govt.

1.10.3.1.2. The Contractor should comply with the provisions of BOCW Welfare Cess Act 1996 in respect of the work awarded to them by BHEL.

1.10.3.1.3. The contractor should ensure compliance regarding Registration of Building Workers as Beneficiaries, Hours of work, welfare measures and other conditions of service with particular reference to Safety and Health measures like Safety Officers, safety committee, issue of Personal protective equipments, canteen, rest room, drinking water, Toilets, ambulance, first aid centre etc.

1.10.3.1.4. The contractor irrespective of their nature of work and manpower (Civil, Mechanical, Electrical works etc) should register their establishment under BOCW Act 1996 and comply with BOCW Welfare Cess Act 1996.

1.10.3.1.5. Contractor shall make remittance of the BOCW cess as per the Act in consultation with BHEL as per the rates in force (presently 1%). BHEL shall reimburse the same upon production of documentary evidence. However, BHEL shall not reimburse the Fee paid towards the registration of establishment, fees paid towards registration of Beneficiaries and Contribution of Beneficiaries remitted.

1.10.3.1.6. Non-compliance to Provisions of the BOCW Act & BOCW Welfare Cess Act is not acceptable. In case of any non-compliance, BHEL reserves the right to withhold any sum as it deems fit. Only upon total compliance to the BOCW Act and also discharge of total payment of Cess under the BOCW Cess Act by the Contractor, BHEL shall consider refund of the amounts.

1.10.3.2. **PROVIDENT FUND**

1.10.3.2.1. The contractor is required to extend the benefit of Provident Fund to the labour employed by you in connection with this contract as per the Employees Provident Fund and Miscellaneous Provisions Act 1952. For due implementation of the same, you are hereby required to get yourself registered with the Provident Fund authorities for the purpose of reconciliation of PF dues and furnish to us the code number allotted to you by the Provident Fund authorities within one month from the date of issue of the letter of intent. In case you are exempted from such remittance an attested copy of authority for such exemption is to be furnished. Please note that in the event of your failure to comply with the provisions of said Act, if recoveries therefore are enforced from payments due to us by the customer or paid to statutory authorities by us, such amount will be recovered from payments due to you.

1.10.3.2.2. The final bill amount would be released only on production of clearance certificate from PF / ESI and labour authorities as applicable.

1.10.3.3. **OTHER STATUTORY REQUIREMENTS**

1.10.3.3.1. The Contractor shall submit a copy of Labour License obtained from the Licensing Officer (Form VI) u/r25 read with u/s 12 of Contract Labour (R&A) Act 1970 & rules and Valid WC Insurance copy or ESI Code (if applicable) and PF code no. along with the first running bill.

1.10.3.3.2. The contactor shall submit monthly running bills along with the copies of monthly wages (of the preceding month) u/r78(1)(a)(1) of Contract Labour Rules, copies of monthly return of PF contribution with remittance Challans under Employees Provident Fund Act 1952 and copy of renewed WC Insurance policy or copies of monthly return of ESI contribution with Challans under ESI Act 1948 (if applicable) in respect of the workmen engaged by them.

1.10.3.3.3. The Contractor should ensure compliance of Sec 21 of Contract Labour (R&A) Act 1970 regarding responsibility for payment of Wages. In case of

"Non-compliance of Sec 21 or non-payment of wages" to the workmen before the expiry of wage period by the contractor, BHEL will reserve its right to pay the workmen under the orders of Appropriate authority at the risk and cost of the Contractor.

1.10.3.3.4. The Contractor shall submit copies of Final Settlement statement of disbursal of retrenchment benefits on retrenchment of each workmen under I D Act 1948, copies of Form 6-A (Annual Return of PF Contribution) along with copies of PF Contribution Card of each member under PF Act and copies of monthly return on ESI Contribution – Form 6 under ESI Act 1948 (if applicable) to BHEL along with the Final Bill.

1.10.3.3.5. In case of any dispute pending before the appropriate authority under ID Act 1948, WC Act 1923 or ESI Act 1948 and PF Act 1952, BHEL reserve the right to hold such amounts from the final bills of the Contractor which will be released on submission of proof of settlement of issues from the appropriate authority under the act.

1.10.3.3.6. In case of any dispute prolonged / pending before the authority for the reasons not attributable to the contractor, BHEL reserves the right to release the final bill of the contractor on submission of Indemnity bond by the contractor indemnifying BHEL against any claims that may arise at a later date without prejudice to the rights of BHEL.

1.10.3.4. **DEPLOYMENT OF SKILLED / SEMI-SKILLED TRADESMEN**

1.10.3.4.1. The following clause is applicable in case the contract value / contract price is Rs.Five crores and above.

1.10.3.4.2. 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.

1.10.4. **GENERAL**

1.10.4.1. Contractor shall execute the work as per sequence and procedure prescribed by BHEL at site. The applicable erection manuals which are available with BHEL site office are to be referred for compliance and guidance before taking up the work. Any rework on this failure to comply with will be to account of contractor only. BHEL engineer, depending upon the availability of materials, fronts etc., will decide the sequence of erection and methodology. No claims for extra payment from the contractor will be entertained on the grounds of deviation from the method of erection adopted in erection of similar jobs in other projects or for any reason whatsoever.

1.10.4.2. Contractor has to work in close co-ordination with other erection agencies at site. BHEL engineer will co-ordinate area clearance. In a project of such magnitude, it is possible that the area clearance may be less / more at a particular given time. Activities and erection program have to be planned in such a way that the milestones are achieved as per schedule / plans. Contractor shall arrange & augment the resources accordingly.

1.10.4.3. The contractor is strictly prohibited from using BHEL's regular components like angles, channels, beams, plates, pipe / tubes, and handrails etc. for any temporary supporting or scaffolding works or as bed for pre-assembly works. Contractor shall arrange himself all such materials. In case of such misuse of BHEL materials, a sum as determined by BHEL engineer will be recovered from the contractor's bill. The decision of BHEL engineer is final and binding on the contractor.

1.10.4.4. All the works such as cleaning, leveling, aligning, trial assembly, dismantling of certain components for checking and cleaning, surface preparation, fabrication of sheets, tubes and pipes as per general engineering practice and as per BHEL Engineer's instructions at site, cutting, weld depositing, grinding, straightening, chamfering, filing, chipping, drilling, reaming, scrapping, lapping, fitting-up etc., as may be applicable in such erection works and are necessary to complete the work satisfactorily, shall be carried out by the contractor as part of the work within the quoted rate. Major machining work, which is only to be carried out in workshops, will be arranged by BHEL.

1.10.4.5. The work covered under this specification is of highly sophisticated nature, requiring the best quality workmanship, engineering and construction management. The contractor should ensure successful and timely operation of equipment installed. The contractor must have adequate quantity of tools, construction aids, equipments etc., in his possession. He must also have on his rolls adequate trained, qualified and experienced supervisory staff and skilled personnel.

1.10.4.6. The contractor will be responsible for the safe custody and proper accounting of all materials in connection with the work. If the contractor has drawn materials in excess of design requirements, recoveries will be effected for such excess drawls at the rate prescribed by manufacturing units.

1.10.4.7. No member of the already erected structure, platform, pipes, grills, other component and auxiliaries should be cut without specific approval of BHEL engineer.

1.10.4.8. No temporary supports shall be welded on the pressure parts of piping. Welding of temporary supports, cleats, etc. on the boiler columns shall be avoided. In case of absolute necessity contractor shall take prior approval from BHEL Engineer. Further, any cutting or alternation of member of the structure of platform or other equipment shall not be done without specific prior approval of BHEL Engineer.

1.10.4.9. Contractors shall ensure that all their Staff / Employees are exposed to periodical training programme conducted by qualified agencies / personnel on ISO 9001 – 2015 Standards.

1.10.4.10. Contractor has to clear the front, expeditiously and promptly as instructed by BHEL Engineer for other agencies, like piping, Turbine, Generator erection, Cabling, instrumentation, insulation etc., to commence their work from / on the equipments coming under this scope. Sometimes, more than one agencies may have to work in same location. Sometimes it may be required to re-schedule the activities to enable other agencies to commence / continue the work so as to keep the overall project schedule.

1.10.4.11. The terminal points decided by BHEL are final and binding on the contractor for deciding the scope of work and effecting the payment for the work done up to the terminals.

1.10.4.12. For the purpose of planning, contractor shall furnish the estimated requirement of power (month wise) for execution of work in terms of maximum KW demand.

1.10.4.13. If applicable, all boiler, piping layout drawings received from BHEL for pipeline erection to be submitted to Boiler Inspector for approval. After approval of the above drawing, Erection of pipe line to be started. Inspection fee and registration fee as mentioned in Chapter VIII of Special Conditions of contract (Volume-IB in Volume-I Book-II) shall be paid by BHEL.

1.10.4.14. Contractor should obtain the formal statutory clearance from Chief Inspector of Boilers to carry out erection & Welding of piping under IBR purview. Arrangement for the visit of Boiler inspector for field inspection, hydraulic test etc., is in the scope of contractor, and necessary drawing / details only will be given by BHEL.

1.10.4.15. Contractor shall arrange the necessary clearance from statutory authorities like IBR, Electrical Inspectorate, Explosive, etc. including the load test on

Hoists/Handling as required for installation of the plant and equipment and render all assistance, service required in this regard.

1.10.4.16. All the necessary certificates and licenses required to carry out this scope of work are to be arranged by the contractor then and there at no extra cost.

1.10.4.17. Contractor shall submit a copy of license to undertake construction / repair of Boilers & Piping issued by Boiler inspectorate before commencement of Pressure Parts / Piping Erection.

1.10.4.18. Crane operators deployed by the contractor shall be tested by BHEL before he is allowed to operate the cranes.

1.10.4.19. The contractor must obtain the signature and permission of the security personnel of the customer for bringing any of their materials inside the site premises. Without the Entry Gate Pass these materials will not be allowed to be taken outside.

1.10.4.20. Upon completion of daily work, the contractor shall remove from the vicinity of work all scrap packing materials, rubbish, unused and other materials and deposit them in places to be specified by BHEL Engineer.

1.10.4.21. During the course of erection, if the progress is found unsatisfactory, or if the target dates fixed from time to time for every milestone are to be advanced, or in the opinion of BHEL, if it is found that the skilled workmen like fitters, operators, technicians employed are not sufficient, BHEL will induct required additional workmen to improve the progress and recover all charges incurred on this account including all expenses together with BHEL overheads from contractor's bills.

1.10.4.22. On completion of work, all the temporary buildings, structures, pipe lines, cables etc. shall be dismantled and leveled and debris shall be removed as per instructions of BHEL by the contractor at his cost. In the event of his failure to do so, the expenditure towards clearance of the same will be recovered from the contractor. The decision of BHEL Engineer in this regard is final.

1.10.5. **UTILITY POINTS**

1.10.5.1. Number of utility points (Service / plant air, service / plant water, service / washing steam, inert gas (N2) etc., shall be indicated in the P & I diagram. Contractor to locate the utility points as advised by site engineer and shall route the piping to these points as per site conditions, and shall submit as built layout with 'BILL OF MATERIAL' to BHEL for approval

1.10.5.2. The utility points shall be located at convenient point to handle and to be terminated with brass / bronze valve with suitable connection for hose pipe

1.10.6. **DOCUMENTATION**

1.10.6.1. The following information shall be furnished by the bidder within two weeks of award of contract for purchaser's approval:

a) Bar chart covering planned activities at site

b) Detailed organization chart
c) Details of T&P available with contractors with documents proofs.

1.10.6.2. The following information shall be furnished by the bidder after testing and inspection:
Test certificates of various tests conducted at site. All inspection and test certificates shall be signed by BHEL representative also.

1.10.7. **RECORDS TO BE MAINTAINED AT SITE:**

1.10.7.1. Record of Quantity of FREE/Chargeable items issued by BHEL must be maintained during contract execution. Also reconciliation statement to be prepared at regular intervals.

1.10.7.2. The under mentioned Records/ Log-books/ Registers applicable to be maintained.

a. Hindrance Register.
b. Site Order Book.
c. Test Check of measurements.
d. Supply and Consumption Daily Register of Cement and Steel
e. Records of Test reports of Field tests.
f. Records of manufacture's test certificates.
g. Records of disposal of scraps generated during and after the work completion.

VOLUME IA PART-I CHAPTER XI ACCOUNTING OF MATERIALS ISSUE

The material issued to the contractor by BHEL will be accounted as follows:

1.11.1. **ISSUE OF CEMENT**

1.11.1.1. Cement as received from the manufacturer/ stockiest will be issued free of cost to the contractor. The cement shall be provided normally in bulkers and shall be unloaded in the silos (Adequate numbers of cement silo of cumulative capacity of 200MT per 30CUM batching plant or as required for batching plant mobilized other than the capacity mentioned) to be installed by the bidder nearer to their batching plants. Cement unloading arrangements to silo and required manpower support shall be provided by the successful bidder at his own cost.

1.11.1.2. On advance request of the bidder, the cement shall be supplied in 50kg tamper proof sealed Bags for other than RCC works like masonry, flooring works etc. The theoretical weight of each bag of cement for issued purposes will be considered as 50 kg, the contractor shall be accountable for the cement issued to him on this notional weight only. No claim whatsoever will be entertained because of difference between theoretical and actual weight of the bags of cement. The empty cement bags duly accounted for against issue shall be in the custody of the contractor and the same shall be disposed by the contractor as per statutory regulation prevailing in the project.

1.11.1.3. The contractor shall submit to the engineer, a statement indicating estimated quantity of cement required during a quarter, at least two months in advance of the quarter. In addition, the contractor shall also furnish the estimated requirement of cement during a month by the third week of the previous month indicating his requirement.

1.11.1.4. Bidder is responsible for unloading the cement as soon as the arrival of cement, either in silo, if received in bulker or in the weather proof cement storage sheds, if received in bags. Bagged cement shall be stored in a weatherproof sheds having dense impervious bituminous or concrete floors which shall be kept swept clean at all times. The storage arrangements shall be fully completed and approved by the owner before any cement is delivered to site. The construction of cement storage sheds as per the requirement of BHEL, unloading of cement bags, stacking properly in the storage sheds, removal of the sheds after the completion of the work is in the scope of bidder.

1.11.1.5. Bidder is responsible for sampling and testing of cement as per Indian Standard/ Specification/ approved quality plan in the testing laboratory established by the bidder.

1.11.1.6. Bidder is responsible for carrying out design mix as per IS 456/10262 Latest revision and specification, using the cement provided by BHEL and submit the design mix proportions for the approval of BHEL/TSGENCO. The design/trial mix shall be carried out time to time on change of brand/ type of cement supplied by BHEL and suitable adjustments on the quantity of ingredients (sand, aggregates, admixture) of the concrete to get the required workability and durability, shall be the responsibility of the bidder without any extra cost to BHEL.

1.11.1.7. Following shall be limit for the maximum quantity of BHEL issue materials that would be with the contractor at any point of time when work is in progress (excluding what has already been incorporated in the works).

Sl no	Issue of Materials	Max. Qty in Contractor's Store
1.	Cement	Requirement of one month

1.11.1.8. **RETURN OF CEMENT**

Sealed cement bags remaining unused and in perfectly good condition at the time of completion or termination of the contract shall be returned promptly, (within 15 days from assessment) if BHEL/ Engineer is satisfied of the physical condition of the cement. Return of such cement to the project stores/ place as identified within the project area by Engineer/ BHEL will not be entitled to handling and incidental charges. Surplus sealed and good conditioned cement bags will be taken back on weighment basis.

1.11.1.9. **CEMENT CONSUMPTION**

The theoretical consumption of cement shall be based on the following.

i. For design mix concrete as per approved design mix.

ii. For nominal mix concrete work, as per minimum cement as specified or as approved by Engineer-in-charge.

For item of works, where volume mix is permitted in writing by the BHEL, for masonry works, plaster other miscellaneous items, the cement consumption shall be governed by the "Statement of Cement Consumption" attached to the Delhi schedule of Rates of CPWD-DSR- LATEST REVISION unless otherwise specified in the specifications or the drawing of contract or mutually agreed by Engineer-in-charge and contractor.

Actual consumption = Issue – Surplus/ unused quantity of cement returned in good condition by contractor to store. (No sweep cement will be taken back by BHEL).

1.11.1.10. **CEMENT WASTAGE**

Allowable wastage: One and half percent (+1.5%) of theoretical consumption of cement unless specified otherwise in the technical specification.

For any material issued by BHEL to the contractor free of cost, and which is not accounted by the contractor to BHEL, then recovery for such material shall be effected at penal rates.

Sl No	Cement consumption	Basis of issue & penal recovery
C-1	Theoretical consumption (without considering any wastage or loss).	Free
C-2	Actual consumption being Limited to one and half percent (+1.5%) of aforesaid theoretical consumption towards allowable wastage.	Free
C-3	Actual consumption beyond one and half percent (+1.5%) of above (C-1).	Penal rate

1.11.2. **ISSUE OF STEEL**

1.11.2.1. The steel shall be issued to the contractor on the following basis:

a) Structural Steel — Weighment basis (Unit – MT)
b) Reinforcement Steel and Earthing rod (MS round) — Weighment basis (Unit – MT)

1.11.2.2. All the steel (structural, reinforcement, earthing MS rod,) issued by the BHEL shall be properly accounted for. The total quantity of steel required for the work will be calculated from the approved Bar Bending schedule, fabrication drawings, approved laps, chairs and lugs. The measurement for payment as well as for accounting shall be based on the sectional weights as indicated in the following IS specifications. No rolling tolerances shall be accepted in any case for issue, return, reconciliation & payment purpose.

IS: 808- latest revisionBeams, Channels and Angles
IS: 1730- latest revision Plates, Sheets and Strips/Flats
IS: 1732- latest revision Rounds including deformed high yield strength bars.

1.11.2.3. In case any such sectional weights are not available in the above documents, the manufacturer recommendation shall be binding.

1.11.2.4. The steel issued to the contractor shall be mainly in standard length and sections as received from the supplier. However, the contractor shall be bound to accept the steel in length as available in the project stores no claims for extra payment because of issue of non-standard length will be entertained.

1.11.2.5. The contractor shall satisfy himself of the quality and quantity of the materials at the time of taking delivery from BHEL stores. No claims whatsoever will

be entertained by BHEL because of quality or quantity after the materials are taken by the contractor from BHEL stores.

1.11.2.6. The contractor shall submit to the engineer, a statement indicating estimated quantity of steel required during a quarter, at least two months in advance of the quarter. In addition, the contractor shall also furnish the estimated requirement of steel during a month by the third week of the previous month indicating his requirement.

1.11.2.7. Following shall be limit for the maximum quantity of BHEL issue materials that would be with the contractor at any point of time when work is in progress (excluding what has already been incorporated in the works).

Sl no	Issue of Materials	Max. Qty in Contractor's Store
1.	Reinforcement Steel & Earthing rod MS round	Requirement of one month
2.	Structural Steel	Requirement of one month

1.11.2.8. Bidders to ensure that no lamination materials are taken over by them from BHEL.

1.11.2.9. Fabrication wastage, if any due to above, shall not be compensated by BHEL.

1.11.2.10. Bidder to note that steel materials required for MS Grating, Galvanised Grating, GI Handrail, Stainless Steel Handrail, Stainless steel for SS Flue can, fasteners like MS/HT/HSFG bolts/nuts, lock nuts, washers and foundation bolts, embedded items other than those supplied by BHEL, etc shall be supplied by the bidder. However, Bidder shall use the scrap materials for their use in the permanent works as embedment/inserts etc. after necessary store issue formalities and shall be accounted for monthly reconciliation.

1.11.2.11. **RETURN OF MATERIALS**

All surplus steel and all wastage materials will be taken back on weighment basis.

Surplus, unused and untampered steel shall be sorted section-wise and returned separately for a place directed by BHEL/Engineer within the project area. Return of such materials will not be entitled to any handling and incidental charges.

All wastage/ scrap (including melting scrap, wastage, un usable scrap) shall be promptly returned to the stores and a receipt obtained for material accounting purposes. Return of such material will not be entitled to any transportation and incidental charge.

1.11.2.12. **SCRAP & SERVICEABLE MATERIALS:**

1. All Structural steel of length above 2 M except M.S. Plate shall be considered as serviceable materials provided the materials is in good and acceptable condition. Structural steel in length less than 2 M shall be treated as scrap.
2. Plates having both sides greater than 1 Metre or if any side is less than 1 M but greater than 0.5 M and the total area is equal or greater than 2 Sq. Metre shall be considered as serviceable.
3. All pipes measuring 2 M and above in length shall be treated as serviceable materials provided they are in good and acceptable condition. Pipe in less than 2 M length shall be treated as scrap.
4. All TMT measuring 3 M and above in length shall be treated as serviceable materials provided they are in good and acceptable condition. TMT in less than 3 M length shall be treated as scrap.

1.11.2.13. **STEEL CONSUMPTION AND WASTAGE**

1.11.2.13.1. **REINFORCEMENT AND EARTHING ROD MS ROUND STEEL CONSUMPTION AND WASTAGE.**

a) CONSUMPTION

The theoretical consumption of various sections and/or diameter of reinforcement and earthing rod steel shall be based on approved construction drawing and bar bending schedule. Weight shall be calculated considering the sectional weights as per Indian standards. No extra cost shall be payable to the contractor for any deviation in weights for the different procedures adopted for issue and calculation of the theoretical consumption including rolling tolerances.

i. Actual consumption = Issue – Surplus

ii. Surplus = Un-tampered & unused quantity of steel and Serviceable materials as stipulated under clause “Scrap and Serviceable Materials (Refer Clause 1.11.2.12 above)” returned by the contractor to BHEL store along with relevant documents.

iii. Wastage = Actual consumption – Theoretical consumption.

b) WASTAGE

ALLOWABLE WASTAGE: - (+3%) of the theoretical consumption shall be considered as allowable wastage. Invisible wastage (max limit to

0.5%), if any, shall be considered to be included in the specified 3 % allowable wastage.

Sl .No	Consumption of reinforcement steel & Earthing rod, MS round	Basis of issue
R-1	Theoretical consumption (without considering any wastage, scrap or loss) as per spec. & drg.	Free
R-2	Wastage limited to plus three percent (+3%) of the aforesaid theoretical consumption (R-1) towards allowable wastage including invisible wastages (invisible wastages limited to 0.5% of theoretical consumptions)	Free
R-3	Wastage beyond three Percent (3%) of the aforesaid theoretical consumption (R-1)	Penal Rate

1.11.2.13.2. **STRUCTURAL STEEL, (ROLLED SECTION, PLATES ETC.) CONSUMPTION & WASTAGE.**

a) CONSUMPTION

The theoretical consumption of various sections shall be based on approved drawings. Weights shall be calculated considering the sectional weights as per Indian standard. No extra shall payable to the contractor for any deviation in weights for the two different procedures adopted for issue and calculation of the theoretical consumption including rolling tolerances.

i. Actual consumption = Issue – Surplus.

ii. Surplus = Un tampered & unused quantity of steel and Serviceable materials as stipulated under clause “Scrap and Serviceable Materials (Refer Clause 1.11.2.12 above)” returned by the contractor to BHEL store along with relevant documents.

iii. Wastage = Actual consumption – Theoretical consumption.

b) WASTAGE

Allowable wastage: - 4% (FOUR percent) of the theoretical consumption shall be considered. Wastage shall be considered as cut pieces and scrap material, measured as per actual weightment basis.

Invisible wastage (max limit to 0.5%), if any, shall be considered to be included in the specified 4 % allowable wastage.

Sl.no	Consumption of structural steel (rolled section, plates)	Basis of issue
S-1	Theoretical consumption (without considering any wastage, scrap or loss) as per spec. & drg.	Free
S-2	Wastage limited to plus Four percent (+4%) of the aforesaid theoreticalconsumption (S-1) towards allowable wastage including invisible wastages (invisible wastages limited to 0.5% of theoretical consumptions)	Free
S-3	Wastage beyond four Percent (4%) of the aforesaid theoretical consumption (S-1)	Penal Rate

1.11.3. **RECONCILIATION OF MATERIALS**

The contractor shall submit a reconciliation statement of steel issued to him with each RA Bill. At the time of submission of bills, the contractor shall properly account for the material issued to him as specified herein to the satisfaction of BHEL certifying that the balance materials are available with contractor's custody at site.

At the time of submission of bills by the contractor, if it is noticed by BHEL that the wastage is high and calls recovery at the penal rate, then, BHEL will proceed for recovery for the excess wastage as per penal recovery rates as specified.

The reference drawings for actual material consumption to be used for the purpose of reconciliation shall be drawings prepared by the BHEL and drawings approved by BHEL for fabrication works and such other drawings approved by BHEL. This shall also include the bar bending schedule prepared by the contractor and approve by BHEL.

1.11.4. **RECOVERY OF MATERIAL**

Recovery of wastages shall be made from the bills of contractor at the penal rate mentioned in the table below for the following cases:

a) If wastage exceeds the specified limit

b) If the wastage not exceeded specified limit, but not returned to BHEL store except invisible wastage

c) For not returning the surplus serviceable materials

1.11.5. **PENAL RATE OF MATERIALS**

A	**REINFORCEMENT STEEL HCRM** Cold rolled steel, high strength, deformed bar or mild steel round bars including earthing rod MS round	**Rs. 64,785/- per MT** + GST and/or other taxes & duties
B	**STRUCTURAL STEEL – Long Products** Rolled steel Beams, channels, and angles, etc. in sizes and lengths as available.	**Rs. 69,347/- per MT** + GST and/or other taxes & duties
C	**STRUCTURAL STEEL – Flat Products** MS plates, MS flats, MS pipes, Chequered Plates, etc. in sizes and lengths as available	**Rs. 81,428/- per MT** + GST and/or other taxes & duties
D	**CEMENT OPC 53 GRADE**	**Rs. 3,987/- per MT** + GST and/or other taxes & duties

VOLUME-IA PART – I CHAPTER - XII
PROGRESS OF WORK

The scope of work will comprise of following but not limited to the following:

PROGRESS AND MONITORING OF WORK

1.12.1. Refer forms F -14 and F-15 furnished in Volume IA, Part II, Chapters 7 & 8 as well as forms F-16 to F-18 of Volume ID (Forms & Procedure) of Volume -I Book-II. Plan and review will be done as per the formats.

1.12.2. Contractor is required to draw mutually agreed monthly construction programs in consultation with BHEL well in advance monthly as per the Form-14. Contractor shall ensure achievement of agreed program and shall also timely arrange additional resources considered necessary at no extra cost to BHEL. Progress review meetings will be held at site during which actual progress during the week vis-a-vis scheduled program shall be discussed for actions to be taken for achieving targets. Contractor shall also present the program for subsequent week. The contractor shall constantly update / revise his work program to meet the overall requirement. All quality problems shall also 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 nonconformities.

1.12.3. The contractor shall submit daily, weekly and monthly progress reports, manpower reports, materials report, consumables (gases / electrodes / ferules / lugs) report, T&Ps availability report and other reports as per Performa considered necessary by the Site Engineer as per the BHEL formats.

1.12.4. The contractor shall submit weekly / fortnightly / monthly statement report regarding consumption of all consumables for cost analysis purposes.

1.12.5. The monthly report ending on 24th of every month shall be submitted as a booklet and shall contain the following details: -

a) Colour Progress photographs to accompany the report should be submitted.

b) Construction progress in terms of quantity, CUM, etc., completed as relevant to the respective work areas against planned.

c) Site Organization chart of engineers & supervisors as on 24th of the month with further mobilization plan.

d) Category- wise man hours engaged during the previous month under the categories like fitters, electricians, welders, riggers, khalasis, grinder-men, gas-cutters, crane operators, store keepers, lab technicians, helpers, security, etc. Data will be spilt up under the work area.

e) Consumables report giving consumption of all types of gases and electrodes during the previous month.

f) Availability report of cranes/ T&Ps

g) Safety implementation report in the format

h) Pending material and any other inputs required from BHEL for activities planned during the subsequent month.

1.12.6. The manpower reports shall clearly indicate the manpower deployed, category wise specifying also the activities in which they are engaged.

1.12.7. During the course of construction, if the progress is found unsatisfactory, or if the target dates fixed from time to time for every milestone are to be advanced, or in the opinion of BHEL, if it is found that the skilled workmen like fitters, operators, technicians, etc. employed are not sufficient, BHEL will induct required additional workmen to improve the progress and recover all charges incurred on this account including all expenses together with BHEL overheads from contractor's bills.

1.12.8. It is the responsibility of the contractor to provide all relevant information on a regular basis regarding construction progress, labour availability, equipment deployment, testing, etc.

1.12.9. The progress reports shall indicate the progress achieved against plan, indicating reasons for delays, if any. The report shall also give remedial actions which the contractor intends to make good the slippage or lost time so that further works can proceed as per the original plan the slippages do not accumulate and affect the overall programme.

1.12.10. The contractor to reflect actual progress achieved during the month and will be submitted to BHEL, so that slippages can be observed and necessary action taken in order to ensure that the situation does not get out of control will update the construction schedule forming part of this contract each month.

VOLUME-IA PART –I CHAPTER -XIII
MATERIAL HANDLING

1.13.1. Open land as available shall be provided by BHEL on free of cost basis. Contractor shall maintain one centralized fenced store cum bar bending yard. Hard surfacing of this yard and all round drain shall be carried out by the contractor at his own cost within the quoted rate. Batching plant area, shall be provided nearer plant premises and contractor shall make use of the area for installation and operation of the Batching Plant at his own cost. The bidder shall make complete arrangement of necessary security personnel, to safeguard all such materials in his custody. Materials issued will be used only for construction of permanent work. The contractor shall take care of material issued by BHEL and shall protect the same from theft, damage and weathering.

1.13.2. The system for receipt, storage & issue of materials shall be available with vendors for easy traceability.

1.13.3. Periodic audit of system of purchasing, storing and issue, etc. will have to be carried out by the vendors. BHEL will also audit the same.

1.13.4. The contractor shall construct waterproof cement store (capacity 400MT) for initial period for storing and stacking of cement, CGI/ asbestos roofing (slope) with brick masonry wall, PCC flooring. Materials required for the same shall be provided by contractor at his own cost. Cement has to be kept over wooden raised platform. Stacking of cement is to be done as per IS codes with proper illumination and locking arrangements.

1.13.5. The contractor shall in no case be entitled for any compensation or damages on account of any delay in supply or non-supply thereof for all or any such material.

1.13.6. Clotting of cement and excessive rusting of steel must be avoided. In case, due to any cause attributable to the contractor, rusting of steel for BHEL issued steel occur rendering the same unusable, then such quantity of cement and steel shall be recovered from the interim payment at the penal rate specified in the tender.

1.13.7. The contractor shall maintain proper store account for all the BHEL issued materials and shall give three copies of once in two months computerized reconciliation statement of such account to the BHEL.

1.13.8. All TMT shall be stacked over sleeper's diameter wise.

1.13.9. All structural steel (issued for insert/ embedment) shall be stacked plate size wise and thickness wise beams, channels and angles shall be stacked separately on sleepers.

1.13.10. Materials shall not under any circumstances taken out of the project site unless otherwise permitted by BHEL.

VOLUME-IA PART-II CHAPTER-1

CORRECTIONS / REVISIONS IN SPECIAL CONDITIONS OF CONTRACT, GENERAL CONDITIONS OF CONTRACT AND FORMS & PROCEDURES

Sl.No.: 1

Clause 4.1.11 of SCC is deleted.

Sl. No.: 2

OCCUPATIONAL HEALTH, SAFETY & ENVIRONMENT MANAGEMENT/ QUALITY ASSURANCE PROGRAMME

The following clauses in Occupational Health, Safety & Environment Management / Quality Assurance Programme published in Chapter-IX of Special Conditions of Contract (Volume I Book-II) is revised as under.

Chapter IX Clause 9.1 is modified as below:

Contractor will comply with HSE (Health, Safety & Environment) requirements of BHEL as per the "HSE Plan for Site Operations by Subcontractor" (Document No. HSEP: 14 Rev 01) enclosed.

Chapter IX Clause 9.1.1 to 9.1.25 stands deleted.

Chapter IX Clause 9.2 to 9.62 stands deleted.

Sl No.: 3

Clause No. 10.5 on RA Bill Payments, in Special Conditions of Contract (SCC), Volume- IB, Book- II, is revised as under:

The payment for running bills will normally be released within 30 days of submission of running bill complete in all respects with all documents. It is the responsibility of the contractor to make his own arrangements for making timely payments towards labour wages, statutory payments, outstanding dues etc., and other dues in the meanwhile.

Sl No.: 4

The following clause is added under clause 1.10 Security Deposit in General Conditions of Contract (Volume I Book II):

1.10.8 Bidder agrees to submit security deposit required for execution of the contract within the time period mentioned. In case of delay in submission of security deposit, enhanced security deposit which would include interest (Base rate of SBI + 6%) for the delayed period, shall be submitted by the bidder. Further, if security deposit is not submitted till such time the first bill becomes due, the amount of security deposit due shall be recovered as per terms defined in NIT / contract, from the bills along with due interest

Sl. No.: 5

VOID

Sl. No.: 6

PRICE VARIATION COMPENSATION (PVC)

Clause 2.17.5 under The PRICE VARIATION COMPENSATION (PVC) clause 2.17 published in General Conditions of Contract (Volume IC Book-II) is revised as under.

Base date shall be calendar month of the scheduled completion date (i.e. actual start date + scheduled contractual completion period as per letter of intent/ award and/or work order).

Sl No: 7

Procedure 2.3 that forms the part of Forms and Procedures is published as Chapter 11 in Volume IA Part II of this booklet (Volume-I Book-I).

Sl No: 8

Void

Sl. No.: 9

Existing format on Monthly Plan Review with Contractor, as available in Form No F-14 of Volume ID Forms and procedure stands Deleted. Form No.- F-14 (Rev 01) is enclosed.

Sl No.: 10

Existing format on Monthly Performance Evaluation of Contractor, as available in Form No F-15 of Volume ID Forms and procedure stands Deleted. Form No.- F-15 (Rev 03) is enclosed.

Sl. No.: 11

The chapter Reverse auction procedure published in 'Forms and Procedures' of Volume I Book-II stands deleted. (**Explanation:** Reverse auction is not applicable for this Tender).

Sl. No.: 12

Existing format on BANK GUARANTEE FOR SECURITY DEPOSIT as available in Form No F-11 (Rev 00) of Volume ID Forms and Procedure stands deleted. Refer Proforma of Bank Guarantee (in lieu of Security Deposit)- Form WAM 22 provided as Chapter 9 in Volume IA Part II.

Sl No.: 13

Existing format for Integrity Pact, as available in Volume ID Forms and procedure stands Deleted. Revised Format is enclosed as a separate file.

Sl No.: 14

Existing format on No Deviation Certificate, as available in Form No F-03 of Volume ID Forms and procedure stands Deleted. Revised Format is enclosed at Chapter 5 in Volume IA Part II.

Sl. No 15

Clause 2.22 RETENTION AMOUNT published in General Conditions of Contract (Volume IC Book-II) is revised as under:

2.22 RETENTION AMOUNT:

2.22.1 Retention Amount shall be 5% of executed contract value and shall be recovered at the rate of 5% from each Running Bill admitted, including PVC Bills. Alternatively, BG, in line with clause 1.12 of GCC, equivalent to 5% of Contract Value against Retention Amount can also be submitted before payment of first RA Bill. The validity of the said BG shall be initially for the contract period & shall be extended, if so required, up to acceptance of final bill. In case of increase in contract value, additional BG for 5% of differential amount shall be submitted by Contractor before payment of next RA Bill due. In case, contractor opts cash deduction from RA bills in the beginning & subsequently offers to submit BG later on, then refund of deducted retention amount may be permitted against submission of equivalent BG only once during the contract period.

2.22.2 Refund of retention amount shall be as follows:

100% of Retention Amount/ BG against Retention Amount shall be released along with Final Bill after deduction of all expenses/ other amounts due to BHEL under the contract/ other contracts entered into with them (contractor) by BHEL.

Note: PROFORMA OF BANK GUARANTEE (in lieu of RETENTION AMOUNT) enclosed in Volume IA Part II Chapter 13.

VOLUME-IA PART – II
CHAPTERS 2 to 13

Chapter 2 to 13 in next 821 pages as below

Chapter	Description	No. of Pages
Chapter-2	General Technical Specifications and Borelog data (Book 1 of 2)	455
	General Technical Specifications and Borelog data (Book 2 of 2)	217
Chapter-3	Drawings	11
Chapter-4	Technical Specification of Labour Colony	10
Chapter-5	No Deviation Certificate (Rev. 01)	01
Chapter-6	"HSE Plan for Site Operations by Subcontractor" (Document No. HSEP: 14 Rev01)	82
Chapter-7	Format for Form no.: F-14 (Rev 01); Monthly Plan and Review with Contractors	05
Chapter-8	Format for Form no.: F-15 (Rev 03); Monthly Performance Evaluation of contractor	08
Chapter-9	Pro forma for Bank Guarantee (in lieu of Security Deposit)	03
Chapter-10	Procedure 2.3-Procedure For Conduct Of Conciliation Proceedings	11
Chapter-11	T&P Hire Charges (Valid upto 31.08.2023)	12
Chapter-12	Proforma for Bank Guarantee (in lieu of Earnest Money)	03
Chapter-13	Proforma for Bank Guarantee (in lieu of Retention Amount)	03

5X800MW TSGENCO YADADRI TPS (UNIT 1 TO 5)

TECHNICAL SPECIFICATION
FOR
NATAURAL DRAFT COOLING TOWERS
(TOTAL 2 BOOKS)

BOOK 1 OF 2

Specification No. : PE-TS-417-165-N002

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA – 201301

COOLING TOWER TECHNICAL SPECIFICATION COMPRISE 2 BOOKS:

CONTENTS

SECTION TITLE

BOOK – 1 of 2 – Mechanical Specifications

I Specific Technical Requirements

IA Specific Technical Requirements (Mechanical)
IB Specific Technical Requirements (Elec.)
IC Specific Technical Requirements (C&I)

II Standard Technical Specifications

IIA Standard Technical Specifications (Mechanical)
IIB Standard Technical Specifications (Elec.)
IIC Standard Technical Specifications (C&I.)

III Documents to be submitted by Bidder

IIIA Guarantee Schedule (To be submitted along with the Bid by all Bidders)
IIIB Compliance Certificate (To be submitted along with the Bid by all Bidders)

BOOK – 2 of 2 – Civil Specification

Part-I
Part-II

SECTION I - SPECIFIC TECHNICAL SPECIFICATIONS

YADADRI THERMAL POWER STATION

PROJECT INFORMATION

1	Name of the Project	YADADRI Thermal Power Station
2	Station Capacity	5X800 MW (Coal based)
3	Owner	Telangana State Power Generation Corporation Limited (**TSGENCO**)
4	Site Location	Site is located 7 km from the NH5.
5	Latitude	*16° 42'*20.40 N
6	Longitude	79° 34'41.56 E
7	Nearest Town	30 Km Miryalaguda
8	Nearest Railway Station	6.5 Km Damercherla
9	Nearest Airport	130 Kms (Vijayawada)
10	**Site Conditions**	
	Ambient Temperature	
	Daily minimum (average)	10°C
	Daily maximum (average)	47°C
	Design Ambient Temperature	50°C
	Ambient temperature (performance)	38°C
	Relative Humidity for design / efficiency	48-84 %
	Annual rainfall, mm	600 mm
	Plant Elevation above MSL	85 m above MSL
	Mean Wind Speed	8 km/h
	Wind Pressure	As per the latest revision of IS 875/1987
	Seismic co-efficient	Zone-II as per IS- 1893 (Part-IV)

1.00	**INTENT OF SPECIFICATION:**
1.01	This specification is intended to cover the vetting of thermal design undertaken by BHEL Consultant, manufacture, assembly, inspection and testing at manufacturer's and/or his sub-contractors works, proper packing, delivery at site, transportation, unloading/handling at site, storage at site, site fabrication, site painting, erection including all civil works/ testing/ commissioning at site and performance testing of Natural draft type cooling tower for 5X800MW YADADRI TPS UNIT-1 to 5 including complete Electrical, C&I and Civil Works as specified and as necessary. This specifications is for Five (5) nos. Natural Draft Counter flow Cooling Towers for 5 x 800 MW YADADRI TPS Units-1 to 5 BHEL intends to get this NDCTs package executed by qualified contractors on an item rate basis. BHEL has done the thermal sizing of the NDCTs through its design Consultant and the same is approved by the owner. The owner approved thermal design is enclosed at Section IA along with the General Arrangement Drawing. The NDCT contractor is required to own the owner approved thermal design and GA drawing such that the responsibility of cooling tower performance shall remain with the bidder in all manners. Any questions or clarifications regarding thermal design may be sought by the NDCT contractor to satisfy himself of its veracity. The tentative quantities for thermo-hydraulic components (Fills and distribution system) listed for S.Nos. 24 and 25 of BOQ as per BHEL's Design are indicated in Annexure-1 of section IA and the same is calculated based on the area inside the NDCT at respective levels shown in the GA drawing. If found necessary ''the NDCT contractor may suggest modifications to the thermo-hydraulic components (listed at S. Nos. 24 and 25 in the BOQ) with technical reasoning/analysis/calculations to justify the measures to improve the thermal performance of the NDCT which will be guaranteed by the bidder''. And as such the responsibility of cooling tower performance shall remain with the bidder in all manners. While suggesting justifiable reasons for changes as above the NDCT contractor shall abide by the following constraints. Also, the NDCT contractor shall guarantee the NDCT performance considering these constraints that are inviolable. 1) Civil Design of NDCT Shell, Shell Profile and Shell dimensions at various heights 2) Foundation of NDCT 3) Air Inlet Height 4) Basin & Internal Structure Column-Beam Grid Dimensions and Elevations 5) Water Distribution Ducts 6) Layout of CW Hot water inlet header to Cooling Tower 7) Height and Diameter of NDCT. Once the changes with justifiable reasons/analyses/calculations provided by the NDCT Contractor are accepted by BHEL/Consultant and duly incorporated, the NDCT contractor will vet the final thermal design & GA of NDCT and furnish the Performance guarantee. The thermal design and GA vetted by the NDCT contractor shall be furnished to Customer for approval. The NDCT contractor shall vet the thermal design as above (for the option applicable) within two weeks of award of contract, for further approval by BHEL/customer. The GA drawing already approved by owner may be required to be approved again depending on changes to the thermo-hydraulic components, if any and therefore the NDCT contractor shall furnish the relevant modifications agreed to by BHEL/Consultant to these items (only) keeping the other dimensions frozen for further approval from BHEL/Customer. The complete design and engineering of NDCT shall remain in the scope of BHEL's Consultant. All Mechanical/Electrical/C&I drawings prepared by BHEL Consultant will be reviewed by the NDCT contractor before submission to customer for approval.

As the quantities for thermo-hydraulic components (listed at S.Nos. 24~~.1 to 24.7~~ and 25~~.1 to 25.5~~ in the BOQ) are going to be estimated by the NDCT contractor based on his modified arrangement, no variation in quantities of these items will be permitted during execution.

~~The NDCT contractor is required to estimate the "lump sum" cost of the thermo-hydraulic components based on his modified arrangement, if any and indicate the same separately (and not against the relevant BOQ items given by BHEL at S.Nos. 24.1 to 24.6 and 25.1 to 25.5 in the BOQ). This lump sum cost shall be added to the cost of other BOQ items quoted by the NDCT contractor on item-rate basis to arrive at the total cost of evaluation.~~

No change in the quantities and cost of thermo-hydraulic components shall be allowed during execution due to any reason whatsoever from that quoted during tender stage.

SECTION - I

SPECIFIC TECHNICAL REQUIREMENTS

SUB-SECTION IA - Specific Technical Requirements (Mech.)
SUB-SECTION IB - Specific Technical Requirements (Electrical)
SUB-SECTION IC - Specific Technical Requirements (C & I)
SUB-SECTION ID – Datasheet-A

SUB-SECTION – IA

SPECIFIC TECHNICAL REQUIREMENTS (MECHANICAL)

1.00.00	**DELETED.**
2.00.00	**SCOPE OF EQUIPMENTS & WORKS UNDER THIS SPECIFICATION:**
2.01.01	**Scope (Mechanical):**
	a) Incoming hot water piping, including vertical run, supported on cooling tower, Motorized Butterfly valves on hot water risers. Terminal point for hot water pipe shall be as per enclosed NDCT GA Drg. Welding at terminal point shall be in bidder's scope. Bidder shall also supply a Pressure Gauge & Temperature Gauge at the terminal point. Any reducer/ expander required at the terminal point shall also be in the bidder's scope. b) List of steel which are free supplied by BTG shall be as per Section-VI , Volume-II. c) Inlet louvers, tower fills & fill supports, drifts eliminators, including all supporting structures, fastening arrangements & accessories. d) Screens, along with guides embedded in concrete shall be provided at the outlet of cold water channel. e) Sluice gate with mechanical jack arrangement and guides in each of the cold water outlet channel connection from the cold water basin. f) Manually operated chain pulley blocks, together with the monorails and supporting frames for the handling of screen and gates. g) Knife-edge gate valve/sluice valve in each de-sludge connection and also De-sludge piping up to the disposal point at local storm water drain channels. h) Pipe spools to be embedded in sludge pit walls and terminated with flanged end at suitable distance from outer face of respective wall. i) Water Distribution system consisting of troughs/ Pipes. Hangers & pipe supports & anchoring arrangement for all piping coming under the scope of supply. j) Two (2) Nos. (1+1) sludge pumps (submersible type) complete with electric motors, non-return valve, isolation valve, piping supports, hangers etc. for cold-water basin drainage. The bidder shall terminate pump discharge pipe work into Discharge Header of CW Blowdown pump at a distance of approx. 250 M from sludge pit. k) Counter flanges, bolts, nuts & gaskets for all piping connections in the scope of bidders and also at terminals.
2.01.02	**Scope (Electrical):**
	a) Complete electrical equipment as per specification/ details indicated in Section IIA shall be in bidders' scope. b) The scope of power & control cables & special cables shall be as per section IIA (electrical). c) Base plate, foundation plates, anchor bolts, sleeves, inserts in concrete work for electrical and mechanical equipment & accessories.
2.01.03	**Scope (C & I):**
	a) Removable type Pitot Tube at each hot water inlet- piping header to measure the flow (during performance Guarantee test only). The Pitot Tube shall be left with customer after the completion of the test . b) One no. Pressure Gauge and One no. Temp Gauge at Hot Water pipe header at T.P.

	c) One no. of Anemometer for measurement of wind velocity. d) One no. of Psychrometer. e) Local Control Panel for Sump/Sludge Pumps (Submersible type). f) Level switches for sump/tank level high/normal/low/very low interlocks. g) Actuator for Motorised BFV at inlet of hot water pipes.
2.01.04	**Scope (Civil):**
	a) Complete civil works as detailed in Book 2 of 2 (Civil Specification) including excavation, shoring, dewatering, backfilling, concrete work including shuttering, sand filling, disposal of surplus soil outside plant boundary, formwork including automatic climb form, laser beam survey instruments, fabrication, galvanizing and erection of steel structures and inserts, finishing anchor bolts, RCC sump/duct, laying and testing of hot water pipe line, water proofing, providing PVC water stops and joint fillers, drainage and other ancillary items connected with cooling towers. All faces of concrete structures and steel structures coming directly in contact with water shall be coated with corrosion resistant coating system as approved. The surfaces that would include are inner face of hyperbolic shell, raker column faces, inner faces of cold water basin, fill support structures, hot water distribution ducts & channels, cold water channel etc. The scope of this work shall consist of , but not limited to, the construction of reinforced concrete double curvature hyperbolic shell, ring beams, foundations (including Piling, if required), cold water basins with partition walls, hot water ducts, drain sumps, external drain chamber with associated pipe work, cold water channels with sluice gate up to the terminal point as specified elsewhere, hoists and monorails, primary and secondary hot water distribution troughs, fill support system including columns and beams, drift eliminators, testing of cold water basin for water tightness, external stairs, sludge pit for each basin section, all other staircases/ladders as required, doors and their frames, walkways, platforms, steel fitting, fixture, inserts, including fabrication, hand railing, providing protective measures in concrete and steel materials against effect of water and other chemicals on the completed structure etc. b) Supply & application of painting at site including lettering on the outer wall of the cooling tower as per customer requirement.
2.01.05	The following are also included in bidder's scope: a) One set of special tools & tackles required for maintenance of equipment & accessories in the cooling towers. b) Various drawings, datasheets, calculations, test reports/ certificates, operation & maintenance manuals including "As built drawings" etc. as specified & as necessary. c) Supply of first fill of lubricants for all equipments under this package including second fill/ replenishments as necessary during & after commissioning till handing over of the plant. d) Supply of commissioning spares on as required basis. e) Scope of services shall include but not limited to erection/ testing/ commissioning/ trial run/ performance testing & handing over of cooling towers. Transportation of equipments, material to site, local clearance, storage at site etc. & supply of all labor including supervision personnel, materials, erection tools & tackles etc. as necessary for expeditious execution of works etc. are also included in bidder's scope. It shall be the responsibility of the bidder to arrange all T & P required for the execution of complete job including erection & civil works.
3.00.00	**Equipment & Services to be provided by Purchaser:**
	a. Supply and erection of incoming hot water piping up to bidder's terminal point.

	b. Supply & erection of sludge discharge piping beyond the bidder's terminal point, if applicable. c. Cold-water outlet channels for cooling tower beyond the bidder's terminal point. d. For Electrical, C&I and Civil works, refer Sections IB/IIB, IC/IIC and Book 2 of 2 respectively enclosed herein.
4.00.00	The cooling tower shall comply with standard technical specifications of cooling towers enclosed in section -'II'. In the event of any conflict between Section -'II' & section 'I', the section 'I' shall prevail. In case of any contradiction in different clauses/parts of Section-I or any other clause of specification, the most stringent requirement shall prevail.
5.00.00	DELETED
6.00.00	DELETED
7.00.00	DELETED
8.00.00	**PERFORMANCE TESTING AT SITE**
8.01.00	**Scope:**
	To ascertain the fulfillment of guarantees after completion of erection and commissioning of the cooling tower, contractor shall carry out performance test for all five(5) nos. of NDCT in presence of employer / purchaser at site.
8.02.00	**Codes:**
	The following codes and standards shall be applicable for conducting test unless otherwise modified or supplemented by the enclosed procedure and mutually agreed to between Owner, BHEL and bidder. a) Code ATC-105: Acceptance test code for water cooling towers. (latest Version). b) BS-4485: Specification for Water Cooling Tower. c) BS-1042: Methods for the measurement of fluid flow in pipes. d) BS-3435: Measurement of electrical power and energy in acceptance testing. e) ASME 19.5: Supplements on instruments and apparatus.
8.03.00	**Conductance of tests:**
	Performance testing of cooling tower shall be done to demonstrate the guaranteed cooling water temperature at rated duty point. The cold-water temperature as specified in the specification shall be guaranteed by the bidder for the design conditions of CW flow, range, ambient WBT as specified
8.03.01	The bidder shall submit cooling tower performance test procedure as per ATC 105 for approval & conduct the test as per the approved procedure, in the event of order.
8.03.02	The bidder shall be given permission to inspect the Cooling Tower in advance and ready it for the test.
8.03.03	**Cooling Tower performance shall be tested jointly by Contractor in presence of BHEL and Owner. All the representatives shall jointly record data of test**. a) The responsibility for conducting the test will be with the bidder. b) **All test instruments required for the PG test will be provided by contractor and meets the stipulations of the CTI ATC 105.** c) Calibration of instruments to be used in the test shall be carried out by an approved independent agency. Calibration of instruments should be carried out previous to, but not more than six months before the test. The calibration certificate of the instruments should be valid for the period of test. d) List of instruments to be arranged by the bidder along with the calibration certificates of the instruments to be used and psychometric charts and tables should be submitted to owner for

	approval.
8.03.04	PG test shall be carried out by the bidder after completion of the cooling tower and at a time when the atmospheric conditions are within limits of deviation from the design conditions as specified in this section preferably in the period from May to September.
8.03.05	Performance test shall be carried out based on ambient WBT. The performance curves of the towers showing variation in performance with change in ambient wet bulb temperature, cooling range, relative humidity water loading of the tower etc, required to ascertain the performance of the tower shall be furnished to the successful bidder. Performance curves applicable to 90%, 100% and 110% of the design water flow rate shall be furnished to the successful bidder.
8.03.06	The guaranteed performance of the equipments shall be demonstrated by the bidder after evaluating the P.G. test should the result of the test deviate from the guaranteed values the bidder shall be given an opportunity to modify/rectify/replace the fills and other materials associated with the performance of tower as required to enable it to meet the guarantees. In such cases the PG test shall be repeated within one month from the date on which the equipment is ready for retest and cost of modification, including labour, materials and cost of additional testing shall be borne by the Bidder. The chance for repeat testing will be given only twice during the contract period. All the modifications carried out by the bidder in the Cooling Tower to meet the contractual requirements shall be carried out free of cost to the Owner in other towers (if applicable for the package).
8.03.07	In case the test cold water temperature as determined from the PG test is higher than the predicated value (based on the performance curves). Purchaser reserves the right to accept all the towers after assessing the LD/ Penalty for performance as specified in cl no- 11.00.00.
9.00.00	The makes of all the equipments under this specification shall be subject to purchaser's approval in the event of order.
10.00.00	It is mandatory for the bidder's to furnish along with the bid the deviations if any, whether major or minor in the '**Schedule of Deviations**' only. In the absence of the deviations listed in the '**Schedule of Deviations**', the offer shall be deemed to be in full conformity with the specification not withstanding anything else stated elsewhere in the offer, data sheets etc. **The hidden deviations or stated/ implied deviations in the offer shall not be acceptable and binding on the purchaser**.
11.00.00	**PERFORMANCE GUARANTEES AND LIQUIDATED DAMAGES**
	a) Performance testing of cooling tower shall be done to demonstrate the guaranteed cooling water temperature at rated duty point. The cold-water temperature as specified in the specification shall be guaranteed by bidder for the design conditions of CW flow, range, ambient WBT as specified. In case the test cold-water temperature as determined from the PG test is higher than the predicted value, Owner reserves the right to reject/replace the fills and other materials associated with the performance of the tower. In the event of its acceptance by purchaser, Penalty of 5% of the Cost of NDCT package value shall be deducted. b) The successful bidder shall demonstrate the above guarantees during performance testing at site. The purchaser is, however, not bound to accept the equipment and reserves the right to out rightly reject it if the actual values exceed beyond the plant design limits.
12.00.00	**INSPECTION AND TESTING:**
	Purchaser/ Customer or their authorized representatives shall have the right to inspect at any stage of manufacture & construction, all materials, components & workmanship & testing of material. The bidder shall provide all facilities for inspection & testing without any extra cost to the purchaser/ Consultant.

12.01.00	The contractor/ manufacturer shall conduct the following minimum specific tests to ensure that the equipment shall conform to the requirements of this section and in full compliance with the requirements spelt out in applicable codes and standards.
12.02.00	Material identification and testing of regulating valve assemblies, screen assemblies, all supporting structural assemblies, fills, all nuts and bolts, sluice valves, nozzles and all other applicable components constituting each cooling tower.
12.03.00	Hydrostatic testing of hot water distribution piping regulating valves and all other pressure parts at a pressure and duration as spelt out in this specification.
12.04.00	Visual, dimensional checking of all components of each cooling tower.
12.05.00	Material testing of all components, hydrostatic testing of all pressure parts at a pressure and duration in compliance with this specification, static and dynamic balancing tests of all rotating components such as pump shaft, line shaft, impeller etc. and complete performance testing as minimum for each sludge pump in each cooling tower.
12.06.00	Tests for hoists, chain pulley blocks and all other lifting tackle shall be carried out as per relevant Indian/ equivalent international standards.
12.07.00	Any other tests deemed necessary for safe, reliable and satisfactory operation of the equipment.
13.00.00	**QUALITY PLAN:**
13.01.00	The inspection & testing of the cooling towers & its various components shall be as per quality plans approved by the purchaser/ Customer. Bidder shall submit the quality plans based on the guidelines given in specification & quality plans enclosed herein. The customer hold points of BHEL/ Customer/Customer nominated agency shall be marked in the QP at the contract stage, in the event of order & inspection/ testing shall be carried out as per same apart from various test certificates/ inspection records etc. Following standard QP are enclosed for bidder's guidance: • Cooling tower • Pipes, fittings & pipe work • BF Valves • Chain Pulley Blocks • Gate/ Globe Valves • Submersible Pumps
13.02.00	The quality plans for various electrical, C&I and Civil works are enclosed in respective sections for bidder's compliance.
13.03.00	For equipments not covered above, bidder shall submit QP's for same on the basis of similar guidelines & submit for approval in the event of order.
14.00.00	**Tests at Site:**
14.01.00	After completion of erection and commissioning of the cooling tower, supplier in accordance with cooling tower Institute Bulletin No ATC-105 "Acceptance Test Procedure for Industrial Cooling Tower" shall carry out performance tests of each cooling tower.
14.02.00	Necessary correction curves shall be furnished by the Purchaser to include in Test procedure for correcting the test results for any difference between test and guarantee design conditions.
14.03.00	All mounting and calibrating instruments required for site performance tests shall be arranged by the cooling tower supplier without any extra cost.

15.00.00	**DRAWINGS, CURVES AND INFORMATION REQUIRED: DELETED**
16.00.00	**Successful bidder in the event of award of contract shall furnish the drawings/ documents for all temporary structures, all erection methodologies, bought items or self-manufactured and/or fabricated items.**

1.0	**GENERAL INFORMATION**		
	No. of Cooling Towers required	:	Five (05) Nos.
	Location		Out door
	Duty		Continuous
	Type		Natural draught Counter flow with PVC Splash Bar type
	Finished ground level		EL (-) 1.5 M (RL+ 80.0 M FOR UNIT- 1 &2) EL (+) 1.5 M (RL+ 83.0 M FOR UNIT- 3,4&5)
	Basin Kerb level (Basin Sill Top level)		EL(-) .1 M (RL+ 81.4 M FOR UNIT- 1 &2) EL(+) 2.9 M (RL+84.4M FOR UNIT 3,4&5)
2.0	**DESIGN PERFORMANCE FOR EACH COOLING TOWER**		
2.1	Design Cooling water flow	:	90000 M^3/hr.
2.2	Design ambient wet bulb temp.	:	28.0 ^oC
2.3	Design inlet air wet bulb temperature.	:	28.0 ^oC
2.4	Approach w.r.t. design inlet air wet bulb temperature (viz. 28.0^oC)	:	5.0 ^oC
2.5	Cold water temperature	:	33 ^oC
2.6	Hot water inlet temperature	:	42.5 ^oC
2.7	Cooling Range	:	9.5 ^oC
2.8	Design ambient Relative Humidity	:	45%
2.9	Liquid Handled	:	Clarified Water (refer details of cooling water analysis at Annexure-3)
	a) Total CW Pumping head permissible viz. static head plus frictional losses as below: • Static head w.r.t. Max Water Level • Frictional losses within bidders T.P. with 10% margin • Velocity head	:	Not to exceed 16.3 MWC from Max WL Or 17.4 MWC from FGL
2.10	Maximum permissible drift loss	:	Max. 0.002 %
2.11	Design pressure for hot water distributionsystem	:	6.2 kg/cm^2(g)

2.12	Maximum foundation Diameter (outermost edge of foundation)	:	NA
2.13	Minimum Basin Diameter	:	140 M
2.14	Maximum Cooling tower flow capacity to be considered for design of hot water distribution and cold water channel	:	Min 120% of design CW flow.
3.0	**SPECIAL FEATURES**		
3.1	Basin type		Sectionalized (two compartment) by partition wall. Each basin chamber shall have overflow arrangement and sludge pit end with necessary dewatering arrangement.
3.2	Whether fills are removable	:	Yes
3.3	Fills supporting by nailing acceptable	:	No
4.0	**Cold Water Basin Details**		
4.1	Finished ground level	:	EL (-) 1.5 M (RL+ 80.0 M FOR UNIT- 1 &2) EL (+) 1.5 M (RL+ 83.0 M FOR UNIT- 3,4&5)
4.2	Maximum water level	:	EL (-) 0.4 M (RL+ 81.1 M FOR UNIT- 1 &2) EL (+)2.6 M (RL+ 84.1 M FOR UNIT- 3,4&5)
4.3	Min. Water level	:	EL (-) 1.0 M (RL+80.5 M FOR UNIT- 1 &2) EL (+) 2.0 M (RL+ 83.5M FOR UNIT- 3,4&5)
4.4	Storage capacity between Normal and minimum water levels.	:	6 minutes (Between Max. & Min. Water Level) of Cooling tower design Flow.
4.5	Invert level of CT Basin	:	EL (-)1.5 M (RL+ 80.0 M FOR UNIT- 1 &2) ---at basin centre EL (-)2.08 M (RL+ 79.42 M FOR UNIT- 1 &2) ---at basin periphery EL (+)1.5 M (RL+ 83.0 M FOR UNIT- 3,4&5) ---at basin centre EL (+)0.92 M (RL+ 82.35 M FOR UNIT- 3,4&5) ---at basin periphery
4.6	Invert level of CW Channel near CT level	:	EL (-)1.5 M (RL+ 80.0 M FOR UNIT- 1 &2) EL (+) 1.5 M (RL+ 83.0 M FOR UNIT- 3,4&5)
4.7	a) Depth of Sludge pit b) Submersible type sludge pumps	: :	Suitable for complete dewatering. To include sludge pump submergence & clearance depth below basin/ channel invert level 1 working + 1 standby (Min capacity of 200 cub M / hr)
4.8	Number of sludge pits	:	Sludge pit with isolating valves, and spool pipe shall be provided for individual basin chambers for connection to drainage pipe.
4.9	Number of cold water outlet channels	:	One for each compartment of CW basin. Cold water outlet shall be designed for flow velocity through

			them within 1.2 M/sec during the rated flow from cooling tower, with the minimum water level in the cold water basin. At T.P Bidder to match same as per T.P. Drawing.
4.10	Depth of CW channel		4.4 M from FGL
4.11	Number of screens and gates in common outlet channel	:	One for each compartment of CW basin
4.12	Maximum allowable effective velocity through Cold water channel at Min. Water Level	:	1.2 M/Sec.
4.13	Maximum allowable effective velocity through gates at Min. Water Level	:	1.2 M/Sec.
4.14	Max. allowable effective velocity through screens at Min. Water Level	:	1.2 M/Sec.
4.15	Length of outlet channel including expansion joint in bidder's scope	:	As per terminal point details in Section C1 and details as shown in the enclosed Annexure-2.
5.0	**COOLING TOWER ACCESS DETAILS**		
5.1	Required number of stair cases from ground level up to hot water inlet for convenient access to top & interiors of Cooling tower	:	Two (2) Nos.
5.2	Number of cage ladders from ground floor to cooling tower top.	:	Minimum Four (4) Nos.: Two from reinforced concrete stairs to platform at the top of the tower and other two shall be from ground level itself.
5.3	Internal walkway of platform with hand rails	:	Walkways and platforms shall be provided inside the tower at distribution pipe level. These walkways and platforms shall provide safe and clear access to all sprayers and all distribution pipes. Clear width of walkways shall be 1.5M.
5.4	External walkway platform	:	1.2 M width around the circumference at top and at each aviation lamp levels
5.5	Platform for access of BFV	:	To be Provided by Bidder
6.0	**HOT WATER SUPPLY HEADER TERMINALS**	:	As per terminal point Annex-2 enclosed. CW piping in BHEL scope 3840mm X 20mm thk. shall be terminated with centre line of pipe elevation as shown in sketch. Further Piping from T.P. with isolating Motorized B.F. Valves in each riser shall be in bidder's scope.
7.0	**SCOPE OF SUPPLY :**		
7.1	Cooling tower basin outlet channels/ sump	:	Yes

	and sludge pits		
7.2	Hot water piping to distribution Duct	:	Yes
7.3	Hot water header isolation valves(motorised) on risers	:	Yes
7.4	Flanges/counter flanges for all flanged connections with bolts, nuts & gaskets etc.	:	Yes
7.5	Screen & guide for each cold water outlet sump/ channel	:	Yes
7.6	Stop Log gate with guides and sealing device for each cold water outlet sump/ channel.	:	Yes – Sluice gate / butterfly valve with complete head stock arrangement is required
7.7	Isolation valves in sludge pit	:	Yes
7.8	Drain Piping from sludge pit to terminal point	:	Yes
7.9	Pulley block for lifting each screen and stop log gate in cold water outlet sump/ channel	:	Yes
7.10	All necessary supports, hangers	:	Yes
7.11	Base plates, foundation plates, anchor bolts, sleeves, inserts, bolts, nuts for all equipment supplied	:	Yes
7.12	Drift Eliminator	:	Yes
7.13	**Electrical**		
	As per electrical plant specification	:	Yes
7.14	All related Civil works included	:	Yes
8.0	**MATERIAL OF CONSTRUCTION**		
8.1	Cold water basin, outlet channel/ sump & sludge pit.	:	R.C.C.
8.2	Shell/Casing & Superstructure	:	R.C.C
8.3	Basin partition wall	:	R.C.C
8.4	Internal walk way	:	R.C.C.
	External walkway platform		R.C.C
8.5	Staircase/Ladders	:	R.C.C./ HDG Steel

	Hand rail		Hot dip galvanized steel
8.6	Supporting structures	:	R.C.C.
	Hot water distribution basin	:	R.C.C
8.7	Hot water distribution nozzles	:	High Density Polyethylene or polypropylene or approved equal
8.8	Fills	:	PVC Splash V-bar type of approved make
8.9	Fill support col, beams & trusses	:	R.C.C
8.10	Louvers	:	R.C.C.
8.11	Drift eliminators	:	PVC UV Stabilised
8.12	Fasteners/wetted parts	:	SS-316
8.13	Piping	:	**Above 150 Nb** : Carbon steel plates to IS 2062 internally lined with anticorrosive coal tar epoxy paint of min. 200 Microns DFT, rolled and welded as per IS 3589 **Below and 150 Nb** : IS 1239 (Heavy Grade)
8.14	Hot Water Distribution Pipes (Inside CT)	:	HDG Steel / PVC
8.15	Hot water line valves		
	a) BF Valves	:	Body: CI as per IS-210, FG-260 Shaft: SS304 as per ASTM A-479 Test pressure & duration shall comply with AWWA C504
	b) Sludge pit isolation valves		
	Body	:	CI as per IS-210, FG-260
	Spindle & Trim	:	SS
8.16	Sludge outlet pipe	:	CI IS-1536, LA
8.17	Submersible Pumps	:	Casing: CI as per IS-210, FG-260 Impeller: Stainless Steel
8.18	Sluice gates with rubber seals in cold water outlet channel	:	As per appropriate class of IS: 3042, all mild steel parts to be galvanised.
8.19	Guide for stop log gates	:	SS 316L
8.20	Screen	:	SS -316
8.21	Guide for Screen	:	SS- 316 L
8.22	Bolts, buts & other hardware	:	SS-316 (for wetted) and MS for other

Note:

(a) Carbon /Mild steel parts or structures used in Cooling Tower or its vicinity shall be Heavily Galvanised.

(b) Material of construction for items not specified shall be subject to purchaser's approval during detailed engineering stage, in the event of order.

9.0	Pipe work Painting / Protection of Pipes:		
9.1	Internal surface		Surface preparation : Shot blasting or Grit Blasting. Internal Paint: Application of one (1) coats of each coat 40 to 50 microns) Epoxy resin based red oxide primer followed by adequate no. of coats of coal tar epoxy paint to achieve total DFT of min. 200 microns.
9.2	External surface – over ground piping	:	Surface preparation : Shot blasting or Grit Blasting. External Paint: Application of one (1) coat of (DFT of each coat 40 to 50 microns) Red lead primer followed by adequate no. of coats of synthetic enamel paint to achieve total DFT of min. 200 microns.
9.3	External surface – Burried piping	:	Surface preparation: Shot blasting or Grit Blasting . **External Paint**: (a) As per IS 10221: i) All Primer / coating / wrapping materials and method of application shall confirm to IS:10221 except asphalt/Bitumen material. Materials (Primer / coating / wrapping) as per AWWA-C-203 are also acceptable. ii) Protective coating shall consist of coal tar primer, coal tar enamel coating, glass fiber, tissue inner wrap followed by glass fiber or coal tar impregnated kraft outer wrap or finish coat. iii) Number of coats & wraps, min. thickness for each layer of application shall be as per IS-10221. Number of coats & wraps shall be decided based on soil resistivity as indicated in IS-10221. iv) Total thickness of completed coating & wrapping shall not be less than 4.0 mm. (b) Alternatively, the anti-corrosive protection for buried pipes can consist of anti-corrosive protection coal tar tapes. Material and application of tapes shall conform to IS 15337 or equivalent. These tapes shall be applied hot over the cold coal tar primer in steps of 2mm thickness so as to cover the spiral edges of the first tape by the application of second tape. The total thickness of finished protective coating shall be 4.0 mm minimum.
	INSPECTION AND TESTING		
10.0	Quality Surveillance by	:	Manufacturer, purchaser and customer
10.1	Material testing and identification	:	Required
10.2	Stage inspection to be witnessed by Purchaser and customer	:	Yes
10.3	Hydrostatic test for piping & valves required	:	Yes

10.4	Hydrostatic test to be witnessed by Purchaser and customer	:	Yes
10.5	Field performance test of individual items and the cooling tower as a whole required	:	Yes
10.6	Field performance test to be done by	:	By Bidder
10.7	All tests on the Butterfly valves at manufacturer's works to be witnessed by Purchaser	:	Yes
10.8	All testing instruments by supplier	:	Yes
10.9	Commissioning at site by	:	Bidder
10.10	Mandatory spares	:	Refer Annexure-5

Attachments:

Attachments:

a) Owner approved Thermal & Hydraulic Design Calculations of Natural Draught Cooling Tower (Annexure-1)
b) Owner approved General Arrangement Drawing of Natural Draught Cooling Towers (Sheets 1 to 6) (Annexure-2)
c) Owner approved Design Basis Report for NDCTs (Annexure - 3)
d) Cooling Water Analysis (Annexure - 4)
e) Mandatory Spares (Annexure - 5)

The following are the additional Technical Specifications for NDCTs. In the event of any contradictions or conflict between these specifications and the Sections IA, IB and IC, the stringent of the two shall prevail.

SECTION-A: SCOPE OF WORK

1.0 This specification covers the general requirements of construction and erection features and performance testing and commissioning of Natural Draft hyperbolic cooling towers (NDCTs).

2.0 It is not the intent to completely specify all aspects and details of the structure / works involved. However, the work shall conform in all respects to high standards of engineering and international construction and erection practices. Contractor's workmanship shall be such that the NDCTs are able to perform in continuous commercial operation without problems to the Owner. The Owner shall have the power to reject any work or materials, which in his judgment are not acceptable or not in full accordance with codes and/or international practices.

2.1 Time is of essence in this contract and hence, the NDCT contractor is required to mobilize all plant and machinery, engineers, supervisors and labour in adequate numbers to ensure that the construction work of all the five NDCTs is taken up, progresses and finished simultaneously as per Customer's schedule.

Apart from the above mobilization requirement the NDCT Contractor may consider time saving methods like painting of the shell and laying of Electrical items like GI conductors, cables, etc. lift by lift while constructing the shell. All such innovative measures to speed up construct work is required to be undertaken by the NDCT contractor.

3.0 The Contractor shall furnish all that is necessary and as required and/or demanded by the Owner even if such information is explicitly not sought herein. The scope of work includes, but is not limited to the following.

a) Construction of NDCTs including excavation, foundation, back filling, sand bedding, laying PCC, concreting, reinforcement, etc., providing electrically operated winches, jump formwork systems, separate lifts for movement of materials, passenger lifts to facilitate movement of staff and inspecting officers and proper communication system during construction period. BHEL will not bear any liability for any extra work, which might not have been perceived by the bidder but functionally required. The cost of such work will be entirely borne by the bidder.
b) Reinforced concrete basin including basin drainage, stop log gates & screens including guide frames and gravity conduits / channel up to the terminal point.
c) Material handling systems at CW channel, Sludge Pit, etc. wherever required.
d) Disposal of surplus excavated earth as directed by the Engineer.
e) Supply of all materials required at site for successful operation of NDCTs.
f) Hot water distribution piping system within the terminal points including Risers, Motorized Butterfly Valves, Internal Distribution Pipes, nozzles, fittings and supports.
g) Fill and its supporting frame works.
h) External RCC Staircases, RCC Platforms and Steel/FRP Doors, internal RCC Walkways and external Cage Ladders.
i) Hot dip galvanized MS handrails, fittings, fixtures, inserts etc., wherever required
j) Complete Earthing & Lightning protection and Aviation Warning systems.

k) De-sludging arrangements with knife-edge gate valves and Sludge Pumps, complete with electric motors, NRVs, isolation valves, piping, etc.

l) Water proof painting, Bitumastic or approved equivalent painting for all internal and external surfaces of basin, diagonal columns, fill supporting structure and inside surface of shell, and cement paint for external surface of shell as specified.

m) Supply and erection of hoist and monorails as necessary.

n) All necessary steel work, hardware etc.

o) Aviation Obstruction Lighting System complete with twin AOLs fixtures, brackets, hardware, JBs, Cables, Photo Cells, Lighting and Control Panels, etc.

p) Earthing & Lightning Protection System complete with GI coronal bands, GI down comers, fixtures, brackets, hardware, earth electrodes and risers and earth pits

q) Pitot tubes, Psychrometers, Temperature and Pressure gauges, Anemometers, Level Switches, etc required for performance monitoring and operation of cooling towers.

r) Trial commissioning and testing, including supply of all testing instruments and mounting the same. Also all isolating valves required on the flow measuring stubs shall be supplied by the Contractor during testing.

4.0 TERMINAL POINTS

a. Hot water pipe (as shown in the GA drawing)

b. Cold water channel (as shown in the GA drawing)

c. Earthing & Lightning protection System

2 nos. of pig tails of tower circumferential earth mat for connection with plant earth grid. However earth mat interconnection between the cooling towers is in CT contractor's scope.

d. Lighting, power receptacles & Aviation Obstruction Lighting System

ACDB input terminal and Aviation control panel's input terminal. Input terminals shall be suitable for Owner's 3 core cables.

e. Instrument cables (at instrument junction box)

f. Cables for drain pumps (input terminals of starter panel)

Note: Jointing at terminal points is in CT contractor's scope. If any of the terminal point is not ready, then the contractor shall leave the TP with all necessary jointing accessories such as PVC water stopper in channel etc., for connection by others.

5.0 SPECIFIC COMPLIANCE

It is necessary for the bidder to comply with the following documents/drawings enclosed with this specification:

a. Thermal & Hydraulic Design Calculations
b. General Arrangement of Natural Draught Cooling Towers (Sheets 1 to 6)
c. Design Basis Report

SECTION-B: MECHANICAL WORKS

1.0 GENERAL

The scope of Mechanical works and testing requirements are covered in this section. The specification gives a broad outline of the scope of work and services to be provided by the contractor and it is not the intent of this specification to cover all the granular details of the package. It shall be the responsibility of the contractor to provide all the necessary materials, works and services required to complete the project in all respects, even if the same are not explicitly mentioned in this specification.

All the detailed fabrication drawings shall be prepared by the contractor and got approved by the Engineer-in-Charge. All the latest revisions of relevant Indian and International standards are applicable in this contract.

1.1 MEASUREMENT & PAYMENT

For payment of work done under this section, the actual quantity erected in the NDCT as measured and approved by the Engineer-in-Charge shall be considered for payment. The quantities lost towards wastage, etc., shall be to the contractor's account and no bills toward wastages, etc. shall be entertained.

2.0 FILL

Fills are of PVC Splash type. Fills should be supported in SS 316 L grids with PP Clips in such a manner that movement in both horizontal & vertical directions are arrested. Additional SS/PP tie wire should also be used to ensure that the fills do not fall off position due to failure of clipping arrangement.

The fills should not sag with all the working, scaling and temperature loads envisaged, including the induced vibrations.

The fill shape, size and configuration shown in the GA drawing enclosed with this specification must be followed without deviation. No changes in these aspects will be permitted.

3.0 HOT WATER DISTRIBUTION SYSTEM

Hot water should flow into the RCC Primary Ducts through MS Riser pipes that enter the NDCTs through the air inlet as shown in the enclosed GA drawing. It is preferred that the water discharges into the duct from the bottom.

A RCC Secondary Duct shall receive hot water from the Primary Duct for distribution into specific segments as per design.

The lateral distribution pipes embedded in the Primary and Secondary Ducts are fitted with down-spray type nozzles, which spray water uniformly over the fill. Spray pattern over the fill should be

circular or square, but solid in either case to ensure equal and uniform distribution of water over the fill without resulting in dry spots at all plant loads.

The complete water distribution system should be rigidly secured to the supporting structure as shown in the drawings.

3.1 PRIMARY DUCT

Primary duct is designed as a RCC channel with cast in-situ slab on top (i.e. closed on top). Each primary duct has 2 Nos. of 1000 mm (W) x 1000 mm (B) x 1000 mm (D) min. open surge shafts cum manholes with rungs to access duct bottom. Each primary duct also has a 100 NB drain plug with dummy nut.

The primary duct also acts as a walk way across the tower. Hence, handrails are provided on both sides along the duct.

3.2 SECONDARY DUCT

A Secondary duct is required to distribute hot water over small segments of the circular area which cannot be catered to by the Primary duct. This duct too is designed as a RCC channel but with a cast-in-situ slab on top.

The secondary duct too acts as a walk way. Hence, handrails are provided on both sides along the duct.

3.3 LATERAL PIPES

Lateral pipes are of PVC or other material as shown in the drawings. The pipes should be with Spigot ends so that couplers for jointing are avoided to the extent possible. Reducers, End Plugs, etc. needed for the operation of the distribution system and as shown in the drawings shall be provided by the contractor. All the accessories shall be of the same rating as of the pipe (Class 3 to IS: 4985).

Lateral pipes shall have pre-fabricated holes at desired intervals (as shown in the drawing) for fixing of nozzles. No drilling will be permitted in pipes after these are installed/embedded in HW ducts.

Maximum diametrical tolerance of (+) 1 mm is allowed for the holes. And alignment of holes shall be within + 10 mm tolerance limit. Hence, it is suggested that the contractor make a suitable jig arrangement at ground level to achieve this requirement.

Nozzles should be fixed to the lateral pipes by bolting and tying with Polypropylene (PP) straps as shown in the drawings. In case of additional fastening with PP straps, the straps shall be capable of taking a minimum load of 30 Kg. Necessary accessories for fastening shall be of same material as of the strap. Bolts shall be of SS-304 material.

After installation, the system shall be rigid and leak proof. Care must be taken by the contractor while Lateral pipes are embedded in the side walls of the primary and secondary ducts to ensure that no leakage or failure occurs during commercial long-term operation.

Pipe joints shall be rendered leak proof by proper application of gluing compound and riveting as shown in the drawings.

Alignment of lateral pipes shall be within the tolerance limits specified above for the pre-fabricated holes. All the nozzles shall be aligned to the direction of gravity. The levels of the pipes and nozzles shall be maintained to result in uniform distribution.

3.4 NOZZLES

The nozzles shall be of down-spray type in PP construction. The spray pattern shall be either circular or square with a minimum diameter of 900 mm.

The contractor shall offer a nozzle that achieves the spray pattern and diameter specified at a static head shown in thermal design calculations. The final choice of the nozzle shall be subject to acceptance by the Engineer-in-Charge.

The tolerance on nozzle opening size for discharge shall be limited to ±1% of that shown in the drawings. Contractor shall demonstrate the performance at 80%, 100% and 120% water loads at nozzle vendor premises using a properly designed test rig. The contractor shall submit testing facility details along with test procedure for review and acceptance before under taking the performance test and procurement or supply of nozzles.

Owner reserves the right to witness the nozzle testing at vendor works. Contractor shall submit the nozzle performance curves to the Owner for review and final acceptance of the proposed nozzle type to achieve the performance envisaged in designs and drawings.

In case of any deficiency is found in nozzle performance at a later stage, the Contractor shall provide additional nozzles or nozzles of a better type without any additional cost to the Owner to meet the design requirements.

In case nozzles comprise of two or more parts, assembly of the same shall be either by threaded connection or SS 304 bolting. The Contractor shall submit a sketch/drawing of the nozzle and its fixing arrangement, including two sample pieces along with his offer.

3.5 HOT WATER PIPING

The MS hot water riser piping shall be connected to the Owner's hot water header pipe at the Terminal Point as shown in the drawing. The end connection shall be of welded type. If the terminal points of owner's header pipes are not ready, all the open ends of the pipes shall be covered with polythene sheets to prevent corrosion.

Steel pipes shall be made either by ERW/SAW methods. Steel pipes shall conform to IS: 1239 (Medium grade) and IS: 3589 (Fe 410 grade) as the case may be. Steel plates for pipes shall conform to IS: 2062. For pipe sizes up to 300 NB, seamless long radius elbows shall be used unless otherwise specified. For pipe sizes above 300 NB, mitre bends shall be used.

The Contractor shall provide the necessary civil & structural works, if required for all the independent foundations, thrust blocks, etc supporting the hot water pipe.

3.5.1 Butterfly Valves

Butterfly Valves shall be electrically operated Double flanged type meeting the requirements of AWWA C – 504 or BS: 5155. Necessary cabling for actuators and limit switches, etc shall be provided by the Contractor up to a common Junction Box located near the Staircase.

POD (Proof of Design) Test	: AWWA C – 504
Operating Fluid	: Water at 45 to 50 deg. C
Design Pressure	: 5.0 Kg./Sq.cm
Max. Differential Pressure	: 5.0 Kg./Sq.cm.
Head loss coefficient	: Max. 0.25
Body	: Cast Iron to IS: 210 Grade FG 260 'OR' Fabricated steel confirms to IS:2062/IS:2002
Shaft	: Stainless Steel to AISI 410
Bearing type	: Self-lubricated type
Disc seat	: Nitrile Rubber
Body Seat	: SS 316
Internal Hardware	: SS 304
External Hardware	: High Tensile Steel
Fasteners	: SS 304
Gland Packing	: Teflon
Gaskets, Rings, etc.	: Nitrile Rubber
Accessories	: 2 Nos. of 2NO + 2NC Limit Switches 'OPEN' & 'CLOSE'.

All the butterfly valves shall be complete with graduated position indicator, arrow indicating the flow direction, actuators, limit switches, etc. The valves shall be suitable for erection in any position (Horizontal / Vertical, etc.). The operating mechanism shall be mounted directly on or supported from valve body.

All the butterfly valves shall be provided with hand wheel. Butterfly valves of size 350 NB and above shall be provided with reduction gear units. Valves shall close in clockwise direction. The hand controls shall be dimensioned to guarantee an easy manoeuvre under most severe conditions. The hand controls shall be provided with locking systems to avoid the disk assuming a not desired position during operation. The pulling force required on the hand wheel-rim shall not exceed 30 Kg. when operating the valve under full flow and operating pressure, in case of failure of actuator. The reduction units shall be watertight, complete with lubrication and position indicator.

3.5.1.1 Flanges

For valves designed as per AWWA C-504, flanges shall conform to ANSI B16.1 Class 150 for CI valves and AWWA C-207 Class D for fabricated steel valves. The counter flanges shall conform to AWWA C-207 Class D.

For valves designed as per BS: 5155 the flanges shall be as per BS: 4504. All the flanges shall be of slip-on and flat-face type. Flanges shall be fabricated from steel plates conforming to IS: 2062.

3.5.2 Ball Valves:

Ball valves are envisaged mainly for flow measurement ports. These valves shall conform to IS: 9890 and are of threaded type.

Pattern and Construction : Full bore in single piece

Nominal size : 150 NB

Design pressure : 6 kg/sq.cm

Material of construction : Carbon Steel Valves to IS: 9890

3.5.3 Sluice Gate (if applicable)

The sluice gate shall be of circular opening conforming to IS: 3042 Class – 1, with rising spindle. The materials of construction of the gates shall be as follows:

Frame and Door : CI Grade 20 of IS: 210 with an inside coating of Epoxy coal tar.

Face, seat rings, trim and Spindle Nut : SS 316

Spindles, bolts and nuts : Hot dip double galvanized MS

Each sluice gate shall be furnished complete with extension spindle through extra-strong pipe of required length connected to the floor-stand through stem coupling. The floor-stand shall be provided on concrete floor of the drain box. Each gate shall be furnished with bell-bottom base and

shall 815 mm high, provided with an indicator and open/close positions clearly marked on the stand. The floor-stand shall be furnished with 450 mm diameter hand wheel and wheel-stem coupling to suit the sluice extension pipe.

3.5.4 Miscellaneous

Each hot water header shall have 3 Nos. of 150 NB, 200 mm long MSHDG stubs with threaded or flanged ends (depending on valve ends) for measurement of water flow with Pitot tube. Each stub shall be fitted with 150 NB Ball Valve for isolation purpose. All necessary bolts, washers, nuts shall be of MSHDG.

Each hot water header shall have one number stub for pressure gauge with isolation valve and one thermowel for temperature measurement.

3.6 CONSTRUCTION FEATURES OF M.S. PIPING:

3.6.1 End Preparation, Cutting, etc.

For steel pipes, end preparation for butt-welding shall be done by machining/flame cutting. Socket weld preparation shall be saw/machine cut. All the welding electrodes and other requirements for welding, including any special material, shall be arranged by the contractor.

For tees, laterals, mitre bends and other irregular details, template shall be used for accurate cutting.

3.6.2 General Instructions for Piping Construction

While erecting the field run pipes, the contractor shall check the accessibility of valves, instrument tapping points and maintain minimum head room requirement and other necessary clearances from the adjoining work areas. Irrespective of whether mentioned in the drawings or not, all pipelines shall be given proper slope towards the drain point.

3.6.3 Welding:

a. Before welding the ends shall be cleaned by wire-brushing, filing or grinding.
b. Welding of piping shall be done by certified welders. Welders' qualification shall be as required by ASME Section-IX. Welding at any joint should be completed in one go.
c. Welding under this specification shall be done by a process approved by the Engineer-in-Charge.
d. Automatic or semi-automatic welding shall be done only with the specific approval of the Engineer-in-Charge.
e. As far as possible welding shall be carried out in flat position. In case that is not possible, welding shall be done in a position as close as to the flat position as possible.
f. Downward technique is not allowed in the welding of pipes in horizontal position, unless permitted by the Engineer-in-Charge.

g. Combination of welding processes or usage of electrode of different classes or 'makes' in a particular joint shall be done after the welding procedure has been duly qualified and approved by the Engineer-in-Charge.

h. Welding carried out in ambient temperature of 50°C or below shall be heat-treated.

3.6.4 Alignment & Spacing

a. The pipes joined by welding shall be aligned correctly within the existing tolerance on diameters, wall thickness & out of roundness, which shall be preserved during welding. All flange facings shall be true and perpendicular to the axis of the pipe with bolt holes being off centre, unless different orientations are shown in drawing to match some equipment connections.

b. Components to be welded shall be aligned and spaced.

c. Root opening shall be 1 mm to 2 mm for wall thickness of 2.4 mm or under and for all thicknesses in oxy-acetylene welding. For 2.4 mm and above, root opening shall be 2 mm to 3 mm.

d. Tack welding for the alignment of pipe joints shall be done only by qualified welders. Since tack welds form a part of final welding these shall be executed carefully and shall be free from defects. Defective welds shall be removed prior to the welding of joints.

e. Electrode size for tack welding shall be selected depending upon the root opening.

f. Tack welding should be equally spaced as follows:

For 65 NB pipe and smaller	: 2 tacks
For 80 NB to 300 NB pipe	: 4 tacks
For 350 NB & larger pipes	: 6 tacks

3.6.5 Welding Technique

a. Root pass shall be made with respective electrodes/filler wires. The size of the electrodes shall not be greater than 3.25 mm (10 SWG). Welding shall be done with direct current values recommended by the electrode manufacturers.

b. Upward technique shall be adopted for welding pipes in horizontally fixed position. For pipes with wall thickness less than 3 mm, oxy-acetylene welding is recommended.

c. The route pass of butt-joints shall be so as to achieve full penetration with the complete fusion of root edges. The weld projection shall not exceed 3 mm inside the pipe.

d. Each pass shall be cleared to be made free of slag before the next pass is deposited.

e. In case of deviation from the welding process and electrodes as specified, the contractor shall seek the approval of Engineer-in-Charge before implementing the change.

f. On completion of each run, craters, weld irregularities, slag, etc. shall be removed by grinding or chipping.

g. During the process of welding, all movements, shocks, vibrations or stresses shall be carefully avoided in order to prevent weld cracks.

h. Fillet welds shall be made by shielded metal arc process regardless of thickness and class of piping. Electrode size shall not exceed 10 SWG (3.25 mm). At least two passes shall be made on socket weld.

4.0 BASIN

Basin is divided into two equal parts by a diametrical partition wall. Each NDCT basin compartment shall be provided with a cold water outlet and a drain sump at the opposite ends. A peripheral drain shall be provided with a minimum floor slope of 1:400 towards the drain sump for easy cleaning of the basin. The basin floor itself, in turn will be provided with a slope of 1:120 towards the peripheral drain.

Sludge will be removed using portable pumps, which shall be supplied by the contractor. The Contractor shall make all provisions such as platforms with handrails, discharge piping up to terminal point, etc. for smooth operation of these pumps. Rungs shall be provided up to the bottom of sump in each compartment for maintenance of valves and pumps.

5.0 COLD WATER CHANNEL

Cold water outlet near cooling tower is partitioned into two parts. Each part of cold water outlet shall have Screens and Stop Log Gates as shown in the drawings. Guide frames of Screens and Gates shall be interchangeable.

To obtain proper alignment of the guide channels, a bigger slot will be left in the concrete and after fixing the channels in position the grouting of these channels will be done by secondary grout/concrete so that fixtures do not get disturbed.

Monorails with push trolleys, chain pulley blocks and hooks shall be provided for handling of gates and screens,. The structural arrangement required for the monorails shall also be provided by the contractor as per the approved drawings.

A walkway with handrails shall be provided across the outlet for easy operation of gates and screens. Both the compartments of cold water outlet shall be combined into a gravity channel at the end of the partition wall as shown in the drawings. The combined cold water outlet shall be covered with RCC cast-in-situ slab up to terminal point. Termination of cold water outlet shall be done with PVC water stopper.

5.1 SCREEN

Mesh	: SS 316 L
Mesh Size	: 25 mm x 25 mm to IS: 2405, Part 1
Supporting Frame	: SS 316L slide parts.
Guide Frame (Embedded in Concrete)	: SS 316 L sealing surface
Trash Tray	: SS316
Fasteners	: SS 316

Screens shall freely move inside the structural framework embedded in the concrete walls of the open channel. Screens provided in the outlet channel shall have a trash tray incorporated on the upstream side of the bottom edge of the screen to catch any debris falling down the screen during removal.

5.2 STOP LOG GATE

Standard	: IS: 5620
Guide frame (Embedded in Concrete)	: SS 316 L sealing surface
Gate (including supporting frame)	: IS 2062 Gr. A
Skin plates of gate	: Min. 8thk designed as per IS 5620
Slide Seal	: EPDM Musical note confirms to IS: 11855
Bottom Seal Plate	: SS 316 L
Painting	: Specified elsewhere
Fasteners	: SS 316

Slide gate constructed in hot double-dip galvanized structural steel sections shall be furnished as per the drawings to be given during execution. The gate shall move freely inside a structural framework embedded in the concrete walls of the open channel. The gates shall have a continuous bearing under compression all around the opening ensuring no leakage.

6.0 ACCESS

6.1 STAIR CASE

All stair cases shall be 'Dog Legged'. The minimum clear width of the stairways and platforms shall be 1000 mm. Minimum clear headroom of 2.5 m shall be maintained over platforms and walkways.

6.2 ACCESS DOORS

The doors shall be of single leaf – double skin type and of 2.1 m (H) x 1.2 m (W) size fabricated from 1.25 mm thick MSHDG steel construction. Painting shall be carried out as specified elsewhere. Alternatively, the Contractor may offer these doors in FRP material as well.

6.3 CAGE LADDER

The cage ladder shall conform to IS: 3696. The ladders shall be min. 600 mm wide and made of hot double dip galvanized 75 mm x 6 mm thick flats with 20 mm diameter rungs at 300 mm centres with

stays at every 1.75 m connected to the wall. The ladder shall be provided with a hot double dip galvanized MS cage consisting of 50 mm x 6 mm straps at 800 mm centres with min. five (5) Nos. 50 mm x 6 mm vertical cage flats throughout the complete length of the ladders. Intermediate landing platforms with handrails, as required and/or as shown in the drawings shall be provided.

6.4 WALKWAYS

Walkways shall be min. 1000 mm wide and shall have min. 2.1 m headroom, unless otherwise specified. All walkways shall have safety handrail of min. 1.2 m height on both sides.
6.5 RUNGS

MSHDG rungs of 25 mm diameter shall be embedded in RCC walls wherever required. Each rung shall be 450 mm wide x 150 mm above wall face unless otherwise specified.

7.0 MATERIAL HANDLING FACILITIES

7.1 AT TOP OF SHELL

During maintenance of the tower, to lift the materials like lighting poles, aviation lights, welding machine etc., from ground to the top of the tower, material handling provision to be made at the top of the tower. MSHDG plates of size 300 x 300 x 20 mm shall be embedded in the wall, flush with the outside concrete surface at 1 m C/C on the shell circumference at the top most platform level. Each plate shall have four tapped holes with nuts welded to the back of each hole (for having extra-long thread engagement) for fixing bolts later. The drilled and tapped holes and nuts shall be suitable for 20 mm diameter bolts. Care shall be taken to prevent entry of concrete into the nut and tapped holes. This arrangement is to support a swivelling lifting arm to hoist a load of 1000 kg.

7.1.1 PORTABLE ROTATING TYPE LIFTING ARM

Lifting arms including swivelling brackets, pins, etc. complete shall be provided along with 250 mm diameter CS pulleys. It shall be possible to easily erect/dismantle this arrangement as and when required. All structural steel sections, brackets and inserts such as bolts, nuts, plates, etc., shall be of MS hot dip galvanized.

7.2 FOR SCREEN AND SLIDE GATE IN COLD WATER CHANNEL

Monorail beam at sufficient height shall be provided. A hand operated chain pulley block with traveling trolley of capacity not less than 125% weight of slide gate shall be provided. All other accessories for this system shall also be designed for the same load. Monorails shall be extended outside the cold water channel to lift/lower the equipment from/to the ground level.

Life	: Not less than 20 years
All CI parts	: Grade FG260 of IS: 210
Chain pulley blocks	: IS: 3832, Class 2 duty
Hand operating chain	: IS: 2429 grade 30 pitched & polished

Load Chain : IS: 3109 grade 40

Hook : IS: 7847

MOC of hook : High tensile steel and heat treated as per Clause 7.1 (b) of IS: 3815

Wire ropes/slings : IS: 2266

8.0 HARDWARE

All the hardware immersed in water or in direct contact with water/water spray shall be of SS 304, unless otherwise specified. The hardware not in contact with water or moisture shall be of MSHDG, unless otherwise specified.

10.0 TESTS:

The contractor shall submit detailed QAPs for approval. Typical QAPs are given elsewhere in this document.

10.1 FILL

10.1.1 Material Test

For plastic fills and drift eliminators impact tests shall be done as per ASTM-D-256 and flammability tests as per ASTM-D-635. Density and Vicat softening tests shall also be done. The contractor shall submit test certificates from approved third party laboratories for approval by the owner. All tests on Fills & Drift Eliminators shall conform to CTI STD-136.

10.1.1.1 UV Test for Plastic fills

UV test shall be done as per ISO-4892. Impact test shall be done before and after UV test. Test certificate from approved third party laboratories shall be submitted for approval by the owner.

10.1.2 Dimensional Test & Load Test on Fill

Dimensional accuracy and material thickness will be checked randomly at site. Load Test shall be done on a mock fill assembly. Both the tests will be done in presence of Engineer-in-Charge.

10.2 BUTTERFLY VALVES

Butterfly valves shall meet the proof of Design test and Disc strength test confirm to AWWA-C-504. Seat leak test shall be done in both directions. In case of fabricated valves, UV test on plates 20 mm or above thickness for body, disc and shaft shall be done. Radiography test on 100% butt welds and 10% DPT on fillet welds shall be done in presence of Engineer-in-Charge.

10.3 GATE/BALL VALVES

Material test, DPT for 100% butt welds and 10% fillet welds, assembly fit up and hydraulic test shall be done and certificates of same to be submitted for approval.

10.4 SLIDE/STOP LOG GATE

Material and DPT for 100% butt welds and 10% fillet welds shall be done and certificates of the same shall be submitted for approval. Assembly fit up, Dimensional accuracy and Leak tight test shall be done at site.

10.5 CHAIN PULLEY BLOCKS

Test certificates of material and DTP shall be submitted for approval. Full load test and 25% overload test shall be carried out with all motions and safety features at site.

10.6 HOT WATER PIPES

Certificates of material and welder qualification shall be submitted for approval. Assembly fit up, dimensional accuracy, DPT and NDT (if required) shall be done at site.

10.7 SCREENS

Certificates of material and DPT shall be submitted for approval. Assembly fit-up test and dimensional accuracy shall be done at site.

11.0 VENDORS LIST

S. No	DESCRIPTION	VENDORS
1.	Testing Agency for Fills & D/E	Shriram Labs, New Delhi / CIPET, CHENNAI
2.	Butterfly Valves	AUDCO / FOURESS / KEYSTONE / IL / INTER VALVE/ KIRLOSKAR / DYNAMIC
3.	Structural Steel	SAIL / TATA / JINDAL / VIZAG STEEL
4.	PVC Pipes	SUPREME / FINOLEX / PRINCE
5.	Push Trolley, Chain Pulley Block, Hook & Chain	WMI / INDEF
6.	Red Oxide Zinc Chromate Primer	'APCOMIN' OF ASIAN PAINTS / BISON UNIVERSAL OF BRITISH

		PAINTS / '3100' OF JANSON & NICHOLSON / SYNTHETIC ZINC CHROMATE OF SHALIMAR PAINTS
7.	Epoxy Primer	HINDUSTAN CIBA GEIGY / Dr. BECK & Co / CHEM.E.LEEK
8.	Epoxy Paint	HINDUSTAN CIBA GEIGY / Dr. BECK & Co / CHEM.E.LEEK
9.	Aviation Obstruction Lights	BINOY / INSTAPOWER / AVAIDS
10.	PVC Fills & D/Es	CONTRACTOR'S OWN MAKE / MM AQUA
11.	SS Weld / FRP Mesh	CONTRACTOR'S OWN MAKE / WIRE NETTING INDUSTRIES / JEETMUL JAICHANDLAL / NBC Weld Mesh
12.	Nozzles	CONTRACTOR'S OWN MAKE / VULQUA

This vendor list is tentative and shall be subject to CUSTOMER approval during detailed engineering.

SECTION-C: ELECTRICAL & INSTRUMENTATION

1.0 AVIATION OBSTRUCTION LIGHTING SYSTEM (AOLS)

The aviation obstruction lights shall meet the recommendations of ICAO and all the requirement of Director General of Civil Aviation, India and FAA guidelines in general.

Aviation lights shall be fixed on the top of NDCTs. Type of fixtures shall be as listed below.

Tower height	Type of Light	Description
<= 150m	Type B, Medium Intensity	Red flashing light with directional intensity of 2000cd ± 25%. Flash frequency shall be in the range of 20 to 60 per minute
> 150m	Type A, High Intensity	White flashing light with directional intensity of 200000cd ± 25%. Flash frequency shall be in the range of 40 to 60 per minute

The number of fixtures shall be as given under.

Top diameter	No. of fixtures
<=20 ft	3
20 ft < >= 100ft	4
100 ft < >= 200ft	6
> 200 ft	8

All flashing lights shall flash simultaneously. Low and Medium intensity lights, if applicable should be operated only in night times. High intensity lights should be operated in day time with full intensity (2,00,000 Cd), during twilight times with 20,000 Cd and in night times operates with 2,000Cd intensity. Installation and setting angles for high intensity lights shall conform to table no.6.2 of ICAO / FAA guidelines.

1.1 AVIATION OBSTRUCTION LIGHTS (AOL)

Each AOL fixture shall have 100% standby light i.e. twin type. In case of failure of any operating light, the standby should be activated automatically with auto changeover facility giving hooter feedback. AOL shall be LED type conforming to IP-65 grade protection class. High intensity lights shall have

intensity step changers. The control panel for the AOLs shall be mounted near the main distribution board under the staircase.

1.2 Photoelectric light detectors shall be furnished and installed near NDCTs to monitor the north sky. The detector shall cause the control unit to energize the aviation lighting system with the north sky illuminance. The lighting system may be energized during short periods of decreasing illumination due to abrupt periods of shadow during daylight hours, but shall not be de-energized as the result of short periods of increasing illumination levels due to lighting flashes or stray light sources when overall illumination level is such that the system is operating.

1.3 Temporary warning lights shall be installed during construction and these shall be located above the top most point of the obstruction and shall be shifted as construction progresses. These lights need to be installed only after the level of obstruction is greater than 50 m above ground. Temporary warning lights shall be of four fixtures each with not less than 10 candelas of red light. Power for operation of the temporary lights shall be obtained from the construction power system. Electrical circuits and cables for these lights shall be furnished, installed and maintained by the Contractor during the construction / erection period. These lights shall be operated right from sunset to sunrise.

1.4 The contractor shall provide hand railing around the beacon platforms, if applicable for attending to any maintenance work.

1.5 The AOLs shall be adequately secured to the handrails / parapet wall of the top platform against wind forces.

1.6 All cables shall be supplied and fixed as per relevant IS codes, clamped at intervals of 1000 mm by the side of the ladder. The cables shall be PVC insulated and PVC sheathed / armoured copper conductor of 650/1100V grade heavy duty conforming to IS: 1554 Part – I (latest revision). The cable shall be subject to Owner's approval.

1.7 The contractor shall install weatherproof terminal boxes with cable glands on top of the NDCTs at a location close to the AOLs. Suitable pull boxes shall be provided at convenient locations.

1.8 There will be two incomers – one main and the other stand-by. Automatic changeover facility with manual option shall be provided in case of failure of main incomer. Standby incomer will be disconnected once the main incomer is restored with suitable delay. A 0-30 second delay timer should be provided to prevent change over taking place for very short-term failure. A16 ampere or higher rating circuit for AOLs shall be provided. The aviation warning lights shall be controlled by photoelectric cell facing north sky through contractor. Auto manual operation selector switch shall be provided for 'ON' and 'OFF' operations. A wall mounted, sheet steel enclosed type Distribution Board (DB) shall be supplied and installed at the ground level for below the staircase. It shall have arrangement to receive Owner's PVC cable (size to be intimated later) and shall have an isolating switch and separate switch fuse circuits for feeding the aviation lights. The DB shall be outdoor type dust and vermin proof and shall have a sheet steel thickness of not less than 2 mm and shall have a proper gasket with removable gland plates at top and bottom. The DB shall also house the automatic switching arrangement described above. The board shall be dead front type; all equipment shall be mounted on auxiliary door. The DB shall be provided with two separate and distinct Grounding terminals. The cables and cabling between distribution board, flashing control unit and AOL fixtures shall be in Contractor's scope.

1.9 Lighting fixtures, conduits, junction boxes, etc., shall be properly earthed using GI wire of 14 SWG. Earth wire will run along the entire length of the cable between the fixtures and DB where it will be connected to the earth.

1.10 Contractor's scope includes supply, installation, commissioning and maintenance of the complete AOL system and its cabling until the NDCTs are taken over by the Owner. The scope shall also include the associated civil works.

1.11 AOL system shall be test operated by the Contractor for not less than 12 months from the date of trial commissioning. Equipment and work that fails during the test period shall be repaired or replaced at the option of the Engineer-in-Charge. Upon any failure in this system during the test period, a new test period of 12 months will be required after repair or replacement of the equipment that has failed.

1.12 POWER RECEPTACLES

32A TPNE industrial type switch-socket outlet(s) shall be provided on the top peripheral platform and on landing platforms, if applicable as specified elsewhere.

2.0 EARTHING AND LIGHTNING PROTECTION

The Contractor's scope of supply for lightning protection includes complete system required as per IS: 2309 from air termination rods to earth mat and electrodes, whether specifically mentioned herein or not.

Grounding system shall confirm to IS: 3043. Each air terminator shall be connected to individual earth-pits through individual down conductors and earth conductors. Apart from the above, a coronal band and an earth mat shall be provided for each NDCT. Depending on the number of earth pits, four shall have test links and two shall have pigtails for connecting to main plant earth grid. All structures and equipment (even the one which are not supplied by the contractor but are in the cooling tower area) shall be connected by minimum two parallel conductors to nearest down/earth conductors.

2.1 Material of Construction

Material of conductors used above Ground level shall be of GI with zinc deposition of minimum 610 gm/m^2. All buried conductors are of MS round bars of min. 40 mm diameter.

a.	Air terminator	: 2 m long, 20 dia. Copper rod with pointed tip
b.	Coronal Band	: 75 x 10 thk GI flat
c.	Down Conductor	: 75 x 10 thk GI flat
d.	Earth Conductor	: 40 dia MS rod
e.	Earth Mat	: 40 dia MS rod
f.	Earth Electrode	: 3 m long, 40 dia MS rod
g.	Grounding for Columns & Structures	: 50 x 6 thk. GI flat
h.	Handrails & Steel structures	: 40 x 3 thk. GI flat

i. Grounding for Distribution boards & Control Panels, etc. : 40 x 3 thk. GI flat
j. & Grounding for Power outlets Lighting Fixtures : 14 SWG GI wire

2.2 AIR TERMINATOR

Tip of air terminator shall be pointed and at least 1.2 m above top of cooling tower. Air terminator shall be clamped with heavy-duty GI clamps at a minimum of 3 points to the structure. Air terminators shall be connected to down conductor and coronal band by use of pressure type fittings.

2.3 CORONAL BAND

Cooling tower shall have a coronal band connecting all air terminators provided at the top of the cooling tower. It shall be clamped to structure at 1000 C/C intervals all around.

2.4 DOWN CONDUCTOR

Down conductors shall be connected to Air terminators via the Coronal band at the top of the cooling tower and to the earth conductor at 300 mm above FGL through a test point at 1.2 m above grade. These conductors shall be continuous as far as possible. Intermediate breaks if any, shall be welded to form continuous circuit from top to bottom. Lapping of down conductor by bolting is not acceptable. These conductors shall be embedded in the outer surface of the concrete shell and diagonal columns with a minimum cover of 50 mm. These shall come out of the shell at the top of the cooling tower and at the ring beam level.

Ladders shall be electrically connected to the down conductors at top, middle and bottom by bolted connections.

2.4. TEST LINK

Test link shall be of 50 x 6 thk GI flat with electroplated bolts, nuts and washers. Test link shall be installed in a GI box fixed on the outside surface of the raker column.

2.5 EARTH CONDUCTOR

Earth Conductor shall be connected to down conductor, earth mat and earth pit by welding. Earth conductor shall be taken through approx. 1.3 m long, 100 NB AC pipe filled with PCC (1:3:6).

2.6 EARTH MAT

Cooling tower shall have a circular earth mat of diameter at least 12 m more than the cooling tower sill diameter and laid at 1000 mm below the ground. All the joints shall be of welded type.

2.7 EARTH PIT

Earth Pit shall be constructed as per IS: 3043. Electrodes shall be embedded below permanent moisture level. Minimum spacing between electrodes shall be 600 mm. Earth Pits shall be treated with salt and charcoal, in case average resistance of soil is more than 20 ohm-meters.

2.8 CLAMPS & ANCHORS:

All connections, clamps, anchors, etc. of the lightning protection system shall be made of GI fittings. All joints, unless otherwise specified shall be clamped or bolted (min. 2 Nos. of bolts) to form high pressure contact for a connection of adequate current carrying capacity and mechanical strength.

2.9 VERTICAL AND HORIZONTAL REINFORCING BARS

All vertical reinforcing bars at the top and the bottom portion of the cooling tower shall be electrically connected to the nearest horizontal reinforcing bar and these bars shall in turn be connected to the down conductors. At locations where vertical reinforcing bar is spliced, each of the spliced bar shall be electrically connected to at least one horizontal reinforcing bar which in turn shall be electrically connected to the down conductor. These electrical connections shall be made by winding tightly with not less than five (5) wrapped turns of 14 SWG GI wire.

2.10 TEMPORARY LIGHTNING PROTECTION

Temporary arrangement for lightning protection during construction shall be maintained by connecting the reinforcement bars to two Grounding conductors of minimum size 50 x 6 thk. Temporary protection shall be provided even after the completion of the tower till such time that the permanent air termination rods and various conductors, etc. are installed.

3.0 INSTRUMENTATION
3.1 PRIMARY INSTRUMENTS

a. Thermowel

Thermowel shall be of one piece solid bore type in SS 316 and of step-less tapered design as per ASME PTC 19.3.

b. Temperature Gauge

Range	: 0^o C – 50^o C (linear 270^o arc in metric units)
Accuracy	: + 1% of span
Dial size	: 150 mm
Sensing element	: Mercury in steel with SS Bulb and Capillary
Body material	: Die-cast aluminium
Protection	: IP55
Zero / Span adjustment	: Required
Accessories	: SS Thermowel

TELANGANA STATE POWER GENERATION CORPORATION LIMITED [TSGENCO]

YADADRI THERMAL POWER STATION
[5 x 800 MW]

NALGONDA, TELANGANA, INDIA

SPECIFICATION NO. PE-TS-417-600-C004

TECHNICAL SPECIFICATION FOR NATURAL DRAFT COOLING TOWER

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

VOLUME: VII-D

TECHNICAL SPECIFICATION
FOR
NATURAL DRAFT COOLING TOWER (NDCT)

CONTENTS

CLAUSE NO.	DESCRIPTION	PAGE NO.
1.00.00	INTENT OF SPECIFICATION	VII-D : 3
2.00.00	CODES AND STANDARDS	VII-D : 4
3.00.00	GENERAL PERFORMANCE REQUIREMENTS	VII-D : 4
4.00.00	SYSTEM DESCRIPTION	VII-D : 5
5.00.00	DUTY AND CAPACITY	VII-D : 6
6.00.00	SCOPE OF SUPPLY AND WORKS	VII-D : 7
7.00.00	DESIGN AND CONSTRUCTION	VII-D : 10
8.00.00	DATA SHEET FOR COOLING TOWERS	ANNEXURE - A

VOLUME: VII-D

TECHNICAL SPECIFICATION FOR NATURAL DRAFT COOLING TOWER

1.00.0 INTENT OF SPECIFICATION

1.01.0 This specification is intended to cover supply and installation of Five (5) nos. of Natural Draft Cooling Tower (NDCT) as detailed hereinafter for 5 x 800 MW Yadadri Super Thermal Power Station for Telangana State Power Generation Corporation Ltd. (TSGENCO) at Nalgonda, Andhra Pradesh.

1.02.0 The scope shall include design, engineering, construction of natural draft reinforced concrete hyperbolic cooling tower including all manufacture, assembly/ pre-assembly, tests at manufacturer's works, shop painting, seaworthy packing, complete with all accessories, auxiliaries as specified hereinafter and as required for safe and trouble free continuous commercial operation.

1.03.0 The scope of this specification also includes but not limited to erection/installation, supervision, including unloading, storage and handling at site, site testing, commissioning, trial run, performance and guarantee tests, training of operating personnel, O&M of the plant till commencement of commercial operation and other erection services to ensure trouble free operation and commissioning of the plant

1.04.0 It is not intended to specify completely herein, all details of design and construction of equipment. However, the equipment shall conform in all respects to high standards of engineering, design and workmanship and be capable of performing in continuous commercial operation up to the vendor's guarantee in a manner acceptable to the purchaser, who will interpret the meaning of drawings and specifications and shall be entitled to reject any work of material which in his judgment is not in full accordance therewith.

1.05.0 The provisions of this technical specification are general in nature and cover broad aspects. Technical specification outlines the minimum requirements. However, it would be absolute responsibility of the bidder to collect, interpret, analyze all necessary information / data for the successful design and construction of the cooling tower. Structural safety and successful operation of the tower shall be the total responsibility of the bidder notwithstanding the approval of the owner.

2.00.00 **CODES AND STANDARDS**

2.01.0 The design, construction, manufacture, performance, testing and commissioning of the cooling tower as specified hereinafter shall comply with the requirements of all applicable latest Indian /British/American Standards and Codes of Practice. The latest editions of the following standards and publications shall be followed in particular:

2.01.1 BS 4485 Water Cooling Tower (Part 1 thru' 4)

2.01.2 Cooling Tower Institute of USA, Bulletin ATC-105: "Acceptance Test Procedure for Water Cooling Tower."

2.01.3 PTC-23: ASME Performance Test Code for Atmospheric Water Cooling Equipment.

2.01.4 IS: 11504: Criteria for Structural Design of Reinforced Concrete Natural Draught Cooling Towers.

2.01.5 American Society of Testing Materials

2.02.0 The materials of various components such as PVC, plain and reinforced concrete, bars and steel wires for concrete reinforcement etc. shall be in accordance with relevant Indian Standards or else to applicable American Standards.

2.03.0 In case of any contradiction between the aforesaid Standards and stipulations as per this technical specification as specified hereinafter, the stipulations of this technical specification shall prevail.

Also, in case of any contradiction between this technical specification and stipulations of the enclosed "Data Specification Sheets", the stipulations of the Data Specification Sheets will prevail.

3.00.0 **GENERAL PERFORMANCE REQUIREMENTS**

3.01.0 The cooling tower shall be designed for continuous operation to cool not less than the design flow of water from specified inlet temperature to outlet temperature at a design ambient wet bulb temperature and other design parameters as enumerated in the enclosed Natural Draught Cooling Tower Data Specification Sheets.

3.02.0 The cooling tower shall be designed for continuous operation throughout the year, unless specially stated otherwise in Data Specification Sheet. The guaranteed performance (cold water temperature) shall be achieved at all wind velocities as specified.

3.03.0 The cooling tower shall also give satisfactory performance while handling the specified water during monsoon months, with the range as indicated in Data Specification Sheet.

3.04.0 For arriving at the air properties such as enthalpy, density etc., no correction for altitude shall be considered. All properties shall be taken from the data provided on CTI or BS code corresponding to sea level.

3.05.0 Bidder shall also furnish the following in support of tower design and performance, along with the bid without which the offer is liable for rejection.

3.05.1 Heat balance calculations.

3.05.2 Justification for the outlet air temperature. This could be in the form of operating experience on existing towers or laboratory test on actual fill shape, material and configuration as offered. In the case of laboratory test, Bidder shall indicate correction / scaling factor applied to predict performance of full size tower under field conditions.

3.05.3 Calculations to show the adequacy of tower height to provide the required Draught.

3.05.4 Calculations for tower duty coefficient and performance coefficient.

3.05.5 Sketch showing fill arrangement which should clearly indicate the total depth, horizontal and vertical spacing.

3.06.0 Drift loss of the cooling tower expressed in % of rated capacity shall be limited to as close to zero as possible.

3.07.0 The Bidder shall assume full responsibility in proper design and operating of each and every component of the complete cooling tower as well as the cooling tower as a whole.

4.00.0 **SYSTEM DESCRIPTION**

4.01.0 The natural draught cooling tower will be located inside the plant boundary and will be used for cooling the hot circulating water returning from the condenser and various other heat exchangers. The circulation of water will be maintained by Circulating Water (CW) Pumps and Auxiliary Cooling Water (ACW) pumps located inside C.W. pump house.

4.02.0 The hot circulating water reaching the cooling tower will be raised to the top of the hot water distribution system of the tower. The hot water distribution pipes inside the Tower shall be fitted with spray nozzles to distribute the hot water evenly over the PVC fill located immediately below. The hot water cools by evaporation as it drains through the PVC fill into the cooling tower basin.

4.03.0 The cooled water will be collected in a circular basin located under the cooling tower. The basin shall have a central partition, such that any half of the basin can be cleaned/ repaired while the other half is in use.

4.04.0 Water from the cold water basins will flow through RCC channel to the sump of the C.W. pump house.

4.05.0 The supplie r shou ld preferabl y be i n a po sition to take up maintenance/ overhauling work as a nd when desired by the Owner during whole life of operation of the plant, on service contract and/or piecemeal basis.

5.00.0 **DUTY AND CAPACITY**

5.01.0 Cooling tower shall be capable of cooling the total quantity of hot condensate circulating water and au xiliary cooling water, through the specified 'Range' at the des ign wet bulb temperature and other parameters a s per Data s heet. This c ooling s hall be p ossible e ven wi th the maximum or calm wi nd conditions. The Cooli ng tower sh all be de signed for c ontinuous operation throughout the year.

5.02.0 The basin wall curb level shall be minimum 500 mm above the finished grade floor. The grade level surrounding the cooling tower shall provide for effective storm water drainage away from the tower. Depth of basin from well top shall be suitable for 6 minute storage of rated capacity excluding free board of 300 mm and not less than minimum one (1) metre. B asin slope towards cooli ng sump shall be 1 in 120.

5.03.0 The bidder shall re view the analy sis of water i n circulation. All materials and components furnished under this specification shall be suitable for continuous and reliable operation o f the tower with the water in c irculation. Special care must be ta ken to select and use materi als and components, wh ich will not corrode, leach or be subject to org anic and inorganic depo sits or de structive action leading to subsequent failure or erosion by water droplets or be source of electrolytic corrosion being set-up between component s. Any materials or components, found inadequate for the service during the first 12 months, after commissioning will ha ve to be re placed at site with su itable mater ial of construction in all t owers without an y additional cost to the O wner at a ti me when unit is under shut down.

5.04.0 Re-cooled water from towe r basin will be con veyed through a c oncrete channel to the c irculating water sump for re circulation. Hot water will be delivered to the tower through dis tributing hea ders. Re-c ooled water from tower shall be thoroughl y mix ed to ensure temperature equal ization prior to entering the channel leading to the pumps.

6.00.0 **SCOPE OF SUPPLY AND WORKS**

The following Equipment shall be supplied under this specification.

6.01.0 **General**

- Thermal, mechanical and structural design of cooling tower including all appurtenant civil works.
- Drift eliminators
- Supply at site of all materials and equipment required for construction.
- Construction of cooling tower including all work and services connected herewith.
- Construction of cold water basin, cold water outlet channel/ duct and basin de-sludge arrangement.
- Hot water distribution piping/ducting along with spray nozzle system.
- Supply, shop testing of components and erection of all mechanical equipment, PVC fill, Spray nozzles, etc.
- Complete lightning protection system, aviation obstruction lighting system, earthing including the necessary power distribution arrangement as per technical specification for "Electrical Equipment and Accessories, Vol.V-A & Vol.V-B".

6.02.1 **Detailed Scope of Civil Works**

- Excavation and back filling for columns foundation and substructure below cold water basin level.
- R.C. foundation raft & Cold water Basin, R.C. Shell, R.C. support framework for fill support.
- Hot water distribution duct.

  Painting of concrete surfaces shall be as per Cl. 9.09.00 of volume - VII D.
- Providing and installation of access doors in the shell of cooling tower including the necessary fittings and appliances on Tower Shell. The access doors shall be of heavy duty MS doors dully painted with 3 coats of epoxy paints.

- Main access RC staircase outside the tower up to Hot water Duct top, internal RC walkways and platforms all with necessary galvanized MS pipe handrails.
- Cold water channel outlet into gravity tunnel.
- De-sludging arrangement for each compartment of cold water basin.
- Provision of permanent acc ess ladd er up to top of tower manufactured in galvanized mild steel with adequate back-guards and landing platforms. The ladder s hall c omply wi th a ll applicab le regulations.
- Provision of peripheral drainage around cooling tower as per Cl. 9.11.00 of volume - VII D
- Necessary site clearing and grading all round the tower in accordance with specifications and drawings.
- Water fill test of c old water basi n, cold water outl et channel and tunnel.
- Hydro test of Hot water Duct.
- Supply and erection of all base plates, foundation p lates, anchor bolts, slee ves, nuts , fasteners, e mbedded p arts and any other likewise mat erial required for all electrical and mechanical equipment and accessories to complete the work.
- Rock anchors will not be considered for foundations in any case.
- Preparation and supply of all working drawings required for the work:
- Piling, excavation, dewatering, sh oring and s huttering, bac kfilling around underground structures and dispo sal of s urplus s oil outsi de the plant boundary / to the designated dump yard.

Any other works not menti oned herein, but suffici ently imp lied an d are necessary for completion and proper functioning of the cooling tower.

6.03.1 **Detailed scope of Mechanical works**

- Hot water dis tributions spray system of reliable & effic ient desi gn, along with its supporting arrangement.
- Hot water duct/pipe work along with supports and anchors.

- Gear operated with chain pulley arrangement isolation valves on hot water inlet piping before hot water distribution system to achieve basin maintenance.
- Painting both inside and outside surfaces of steel pipes with three coats of rust and corrosion resisting paint including thorough cleaning of the surfaces.
- Tower PVC fill, drift eliminators including all required supporting structure and accessories, etc. as necessary.
- Screens along with guides embedded in concrete at each of the cold water outlet channels from the cold water basin.
- Sluice gate with mechanical jack arrangement and guides in each of the cold water outlet channel connection from the cold water basin.
- Manually operated chain pulley blocks, together with the monorails and supporting frames for the handling of screen and gates.
- Cold water outlet duct/tunnel.
- Knife-edge gate valve/sluice valve in each de-sludge connection and also De-sludge piping up to the disposal point at local storm water drain channels.
- Tower Fill Hot water By-Pass Nozzle connections on Hot water duct/ piping for system lines flushing during commissioning.
- Instrument tapping provisions on hot water duct/piping and cold water duct/piping for carrying out flow and temperature measurement during PG test.

6.04.1 **Detailed Scope of Electrical Works**

Refer Volume V-B, Section-XV, Technical Specification for Chimney and Natural Draft Cooling Tower- Electrical works.

6.05.0 Any additional equipment, material, services which are not specifically mentioned here, but are required to make the plant/systems in the scope of the Bidder complete in every respect in accordance with the technical specification and for safe operation and guaranteed performance, shall be deemed to be covered under the scope of this specification.

6.06.0 All accessories and hardwares.

6.07.0 One set of special tools and tackles.

6.08.0 All relevant drawings, data and O&M manuals.

6.09.0 The scope of this specification also includes erection, installation, site testing, commissioning, trial run, performance and guarantee tests, training of operating personnel, O& M of the plant till commencement of commercial operation and other erection services to ensure trouble free operation and commissioning of the Equipment/System.

7.00.0 **DESIGN AND CONSTRUCTION**

7.01.0 **Hot Water Distribution System**

7.01.1 The distribution system shall be designed for flexible and satisfactory operation at all reasonable loads.

7.01.2 The hot water distribution shall be suitable for handling an additional 20% flow over the design circulating water flow. The hot water distribution shall be done by two headers, each covering half of cooling tower area so that it can be operated at 50% capacity.

7.01.3 The hot water distribution piping and valves shall be designed for a working pressure as calculated by the Bidder.

7.01.4 The spray system can be either upward or downward maintaining water spray even with shutdown flows.

7.01.5 The sprayers shall be arranged in a uniform pattern with proper distance to produce 10% to 20% overlapping of the individual sprays. This arrangement shall provide extremely even water distribution with uniformly sized droplets entering the fill. The spray overlapping required avoiding dry pockets in the fill due to variations expected in water head availability in main hot water duct.

7.01.6 The spray nozzle shall be reliable and effective in breaking the hot water jet into a spray pattern of uniformly sized droplets. It should be proven and tested design to provide maintenance free service for minimum 3 years.

7.01.7 The fixing arrangement of spray nozzles to hot water distribution header shall be of flanged joint type. Screwed joint shall be avoided as they are likely to get loosened due to flow induced vibrations.

7.01.8 The distribution of water shall be in Ducts / troughs of approved material. The entire water distribution system shall be self-draining and non-clogging type.

7.01.9 The distribution troughs/pipes shall be independently supported from the structures and shall be easily removable. Provision shall also be made for easy flushing or cleaning of all troughs / pipes.

7.01.10 The structural design of the water distribution system shall also consider the following loadings, combined as appropriate.

a) Self-weight.

b) Hydraulic pressure during normal operations, including pressure surges.

c) Hydraulic pressures due to mal-operation of tower or supply pumps.

7.01.11 Seismic loading on the water distribution system shall also be considered.

7.01.12 The water distribution system shall be provided with adequate pressure surge relief facilities to prevent pressure loadings in excess of values used in the design. If such facilities are not provided, a further increase in loading shall be considered in the design. The pressure level to be considered shall not be less than 1.5 times the design pressure.

7.01.13 The design of water distribution system and its supports shall be capable of accommodating all thermal stresses and movements due to changes in inlet water temperature, outlet water temperature and ambient temperature.

7.01.14 If open basin system of distribution is provided, the basin shall be provided with removable type covers made of pre-cast concrete.

7.01.15 Splash boxes in cross flow tower shall be provided at the discharge of each distribution valve to minimize splashing and to facilitate even distribution of water.

7.01.16 The nozzles shall be spaced to give even distribution of water over the entire space occupied by top row of fills.

7.01.17 The nozzles and splash plates shall be made of High Density Polyethylene or approved equal.

7.01.18 The pipes & valves etc. used shall be designed and arranged to take care of the possible thermal stress due to temperature variation. The pipes & fittings shall have extra heavy thickness.

7.01.19 Ready accessibility to the different parts like isolation valves etc. shall be provided and as required necessary platform/walkway and ladder shall be provided for this purpose.

7.02.0 **Louver and Casing**

7.02.1 Louvers shall be de signed for air entry to the tower with low velocity for minimum pres sure drop and less chance of reci rculation of moist ai r. To eliminate splash out, louvers shall slope to shed water inwards.

7.02.2 The louvers and casing may be made of concrete. Concrete casing wall shall be supported from the basin through reinforced concrete. Hinged access door with platforms shall be provided for entry into the tower at suitable locations.

7.03.0 **Fill**

7.03.1 Cooling tower fill shall be made PVC, V-bar type of approved make.

7.03.2 Minimum weight of fill should be 100 Kg/sqm.

7.03.3 The Bidde r s hall en close with his proposal a write-up o n the meth od of replacement of damaged/deteriorated fills during the life of cooling tower. Also Bidder's experience with pre-stressed concrete fills shall be cl early furnished in proposal. Bidder shall also indicate whether these are to be manufactured at shop or at site.

7.03.4 The PVC fi ll if offered shal l be durabl e and fire retardant qu ality. The Bidder shall furn ish detai ls of PVC f ill a long with h is offer i ndicating fire reta rdant properties, ageing effe ct, vibration c aused b y water an d wi nd eff ects. Frequency of rep lacement of PV C fills and the method of such rep lacement shall also b e mentioned with abo ve details. T he PVC fills sha ll be of proven quality and the ma ke and its properties sh all be subject to Purchaser's approval. T he B idder shall furnish wi th his proposal, a sample of the fill material to be used for the specified cooling tower.

7.03.5 Design and facing of the fills shall be such as to expose high air/water surface with minimum air pressure drop. Air velocity through the fills shall be uniform.

7.04.0 **Fill Supports**

7.04.1 Splash b ar type f ills shall be supported on t he grid s at f requent i ntervals, preferably not e xceeding 450 mm, to minimize sag, pos sibility of dislodgement, and damage to f ill materials as a consequence of induced vibration in the fill.

7.04.2 For fi lm t ype filli ng, the s heet like f ills consisting of multiple vertical surfaces shall be tied with filling support bars by stainless steel or nylon wires. Suitable spacers shall be used to maintain verticality of the sheets.

7.04.3 The fill and the support system shall be sufficiently strong to withstand the

water loading when the flow path is 30% chocked.

7.05.0 **Drift Eliminators**

7.05.1 Zig-Zag path type Multi pass Drift eliminators (minimum two pass) shall be provided so as to limit the drift loss to that specified earlier or as in the Data Specification Sheet.

7.05.2 In case the tower is provided with pre-stressed concrete or PVC fill, drift eliminators may be made up of PVC.

7.05.3 The eliminator frame shall be of rugged construction and shall be firmly secured to arrest vibration.

7.06.0 **Access**

7.06.1 Staircases shall be provided external to the cooling tower along with stairways, landings, walkways, handrails and access doors. Minimum 2 Nos. staircase 1000 mm wide and minimum landing width of 1000 mm at locations as necessary to give safe and convenient access to the top and the interior parts of the tower.

7.06.2 Suitable arrangement for supporting walkways inside the cooling tower shall be made and such arrangement shall be independent of the fill material.

7.06.3 Whether specifically mentioned in the Data Specification Sheet or not, steel components and fittings used in walk ways, handrails shall be hot dip galvanized after fabrication.

7.07.0 **Cooling Tower Basin & Outlet Sumps**

7.07.1 The hot water distribution basin and cold water outlet channel of the cooling towers shall be designed by considering a minimum of 10% margin over the design cooling tower flow.

7.07.2 Cooling tower basin, shall be supplied/constructed along with all civil parts, base plates, anchor bolts, nuts, and other accessories, pipe sleeves, inserts, etc. and as required to complete the work in all respects.

7.07.3 The work shall include excavation/back-filling as necessary, all concrete/steel work, cold water outlet sump & sludge pit for each basin, water-proofing and all other works.

7.07.4 The basin shall be partitioned into two individual chambers such that one section can be taken out for maintenance /de-sludging while the other section is in operation.

7.07.5 Sludge pit with isolating valves, and spool pipe shall be provided for individual

basin chambers for connection to drainage pipe.

7.07.6 For each basi n chamber, there shall be a cold water out let su mp. In the connection between bas in c hamber and c old water s ump there sha ll be screen and sluice gate/Butterfly valve.

7.07.7 Each basin chamber shall have overflow arrangement at sludge pit end.

7.07.8 Basin slope towards cooling sump shall be 1 in 120.

7.08.0 **Screens & Isolating Devices in Cold Water O utlet Sumps, Valves and Pipes in Sludge Pits and Accessories**

7.08.1 Screens shall be out of 8 gauge 25 mm clear opening SS wire netting welded to frame o f structural steel se ction/flats. Framewor k shal l be hot di p galvanized and prov ided wi th primer and bitumino us painting. Two numbers of sc reens shall be supplied per t ower. Li fting lugs or e ye bolt s sh all be provided on top of the screen frame for ease of handling.

7.08.2 For handling screens, one set of monorail with supporting structure and chain pulley hoist complete with lifting chain and push type trolley for mounti ng the hoist shall be furnis hed, if as ked for in the Data Spec ification S heets. The chain pulley hoist shall be manually operated a nd shall conform to IS : 3832, Class-2.

7.08.3 Sluice gates or Butterfly valves in cold water o utlet sumps sha ll be pro vided as ment ioned in Data Specification Sheet. Sluice gate s sha ll be as per appropriate class of IS: 3042. Butterfly valves shall conform to AWWA C-504 (latest revision).

All mild steel parts shall be galvanized or painted with epoxy enamel primer & paint. The sluice gate may be rectangular or circular as per preference of the Bidder.

The sl uice gates/B utterfly valves s hall be co mplete wi th head-st ock for manual operation. The head- s tock sha ll have pill ar, b ase pl ate and hand wheel made up of cas t iron. The he ad-stock shall ha ve rising/non-ri sing spindle with position indicator.

7.08.4 The fl ow area through eac h gate/ valve and screen shall be such as to maintain a f low velocity through the m within 1.2 M/se c during the rated flow from cooling tower, with the minimum water level in the cold water basin.

7.08.5 The isolating v alves i n sludge pit s shall conform to appropri ate class of IS : 780. E ach valve shall b e complete with pedes tal type manual opera tor, wi th rising/non-rising spindle and valve position indicator.

7.08.6 The pipe spools, to be embedded in sludge pit for piping connection, shall be

C.I. pipe as per IS: 1536, Class-LA, unless otherwise mentioned elsewhere.

7.09.0 **Hardware**

All nails and fastening bolts, nuts & washers used in the cooling tower stainless steel, if not specified in the Data Specification Sheet.

ANNEXURE-A

DATASHEET FOR NATURAL DRAFT COOLING TOWER

1.0 General Information

Type of Cooling Tower	:	Natural Draft, Hyperbolic
No. of Cooling Towers Required	:	Five
Location	:	Outdoor
Duty	:	Continuous

2.0 Design Working Conditions

Hot water inlet temperature	:	42.0^{o}C
Design Ambient wet bulb temperature (WBT)	:	28^{o}C
Design Ambient temp. for electrical equipment	:	50^{o}C
Design Ambient Relative Humidity (RH)	:	44.96%
Whether inlet air wet bulb temperature to be corrected considering re-circulation as per CTI bulletin PFM-116	:	Yes
Design CT inlet wet bulb temperature	:	By Bidder
Basin Holding Capacity	:	6 mins of design CT capacity
Design Wind speed	:	As per site data

3.0 Performance Requirement

Rated Cooling Water flow	:	By Bidder
Cooling range	:	10.5°C
Approach to ambient wet bulb temperature	:	5.0°C
Maximum permissible drift loss	:	0.002%

Design pressure for hot water distribution system	:	By Bidder
Operating range to be established by cooling tower characteristics curves and performance curves	:	As per Clause no. 5.03.00

4.0 **Special Features**

Type of Tower design. (Bidder to justify his offer)	:	Counter-flow / Cross-flow
Type of fill	:	PVC Splash (V-bar type of approved make)
Whether fills are removable type	:	Yes

5.0 **Material of Construction**

Cold water basin, outlet channel/sump & sludge pit:		R.C.C.
Casing & superstructure	:	R.C.C.
Basin diagonal partition, if any	:	R.C.C.
Staircase	:	R.C.C./HDG Steel
Hot water distribution piping		
Inside Tower	:	HDG Steel/PVC
Outside Tower	:	MS pipes with PVC/FRP Wrap on outside.
Hot water distribution nozzles Equal	:	Polypropylene/Approved
Fills	:	PVC with minimum spacing of 20 mm
Fill Support	:	R.C.C./HDG Steel
Louvers	:	R.C.C.

Drift eliminator	: PVC
Hot water piping	: IS: 3589
Butterfly valve for hot water distribution system/cold water outlet channel	:
• Body	: CI as per IS-210, FG-260
• Di sc	: - do -
• Shaft and spindle	: SS304 as per ASTM A-479
• Shaft bearing	: Lea ded bronze, self-lubricated (BS-1400, LB-2)
• Seat ring	: ASTM A-479, Type 304
• Gland packing	: Impregnated Teflon
• Seal	: Ni trile Rubber, Shore Hardness 50-60 Deg.
• Bolts & Nuts (in contact with water)	: Stainless Steel
	Sludge pit isolation valves:
• Body	: CI IS-210, FG-260
• Spindle & Trim	: Stainless Steel.
• Sludge outlet pipe	: CI IS-1536, LA
• Sc reen	: Anodis ed Aluminium
• Guide for screen	: CI IS-210, FG-260
• Bolts, nuts & other hardware	: Stainless Steel

6.1 **Inspection And Testing**

Quality surveillance by	: Manufacture r/Purchaser
Material testing and identification	: Required
Stage inspection to be witnessed by Purchaser	: Yes

Hydrostatic test for piping & valves required	:	Yes
Hydrostatic test to be witnessed by Purchaser	:	Yes
Field performance test of individual items and the cooling tower as a whole required	:	Yes
Field performance test to be done by Contractor	:	Manufacturer/EPC
All tests on the Butterfly valves at manufacturer's works to be witnessed by Purchaser	:	Yes
All testing instruments by supplier	:	Yes
Commissioning at site by Contractor	:	Manufacturer/EPC

TITLE BLOCK ANNEXURE-1

CUSTOMER	TELANGANA STATE POWER GENERATION CORPORATION LTD TELANGANA INDIA YADADRI TPS (5X800 MW)
CONSULTANT	TATA CONSULTING ENGINEERS LIMITED BANGALORE INDIA
	BHARAT HEAVY ELECTRICALS LIMITED
	SPECTRUM TECHNO CONSULTANTS PVT LTD NAVI MUMBAI INDIA

TATA CONSULTING ENGINEERS LIMITED
VENDOR DOCUMENT REVIEW STATUS

- ☑ A Drawing/Document approved as submitted. Proceed with fabrication/construction.
- ☐ B Drawing/Document approved subjected to comments noted. Proceed with fabrication/ construction considering our commnets.
- ☐ C Our comments are noted on this marked up print.
- ☐ D Our commnets are noted in memo attached to the forwarding transmittal letter No. .....Dated.....
- ☐ E Correct original of this drawing/document to reflect our comments and resubmit for approval.
- ☐ F Correct original of this drawing/document to reflect our comments and resubmit for records.
- ☐ G Drawings/Documents of this category are for information only and not for approval. Information furnished on the drawing/document is noted.
- ☑ H Drawing/Document reviewed against our previous comments and other revisions highlighted and identified by the vendor.
- ☐ I Drawing/Document returned without review.
- ☐ J Print not enclosed.

Approval conveyed herein neither relieves the Vendor/Contractor of his contractual obligations and his responsibilities for correctness of dimensions, materials of construction, weights, quantities, design details, assembly fits, performance requirements and conformity of the supplies with the Indian Statutory Laws as may be applicable, nor does it limit the purchaser's rights under the contract.

Reviewed by MB Date 30-05-2019

COPYRIGHT AND CONFIDENTIAL
The information on this document is the property of
BHARAT HEAVY ELECTRICALS LIMITED it must not be used directly or indirectly in any way detrimental to the interest of the company.

DEPT. CODE		NAME	SIGN	DATE
M	DESN	UNB		28-Nov- 18
	CHD	UNB		28-Nov- 18
	APPD	UKR		28-Nov- 18

TITLE : NATURAL DRAUGHT COOLING TOWER - THERMAL AND HYDRAULIC CALCULATIONS & DATA SHEETS

		DEPT.			DOCUMENT NO. PE-V1-417-165-N003	
		SIGN				
					SHEET 1 OF 14	REV. 2

R0 : 29-MAR-18; R1: 18-JUL-18; R2: 28-NOV-18

Digitally signed by NISHANT SEHEKHAR
DN: cn=NISHANT SEHEKHAR, o=BHEL, ou=PEM, email=nishnatshekhar@bhel.in, c=US
Date: 2018.12.14 11:34:48 +05'30'

S.No.	TSGENCO/TCE Comment dt: 17.07.2018	BHEL/Spectrum Response	TSGENCO/TCE Comment dt: 10.10.2018	BHEL/Spectrum Response dt: 28.11.18
1.	Is there any KaV/L advantage provided for rain zone	The KaV/L gain and the associated pressure drop in the rain zone of a NDCT are significant values and hence, these are accounted for.	Please inform us, what is the percentage gain considered in the rain zone.	There is no fixed percentage for transfer co-efficient gain in the rain zone. It is calculated by the thermal program in an iterative manner since there are many properties of water and air that are involved in the equation. It is not possible to use these transfer equations outside of a program to calculate results. For example, the equation for rain zone transfer co-efficient is as under: $\frac{h_{drz}a_{rz}H_3}{G_w} = 12\left(\frac{D_1}{v_{av3}d_d}\right)\left(\frac{H_3}{d_d}\right)\left(\frac{p_{a1}}{R_v T_{a1}\eta_{ws}}\right)Sc_1^{0.33}\left[\ell n\left(\frac{w_{s1}+0.622}{w_1+0.622}\right)/(w_{s1}-w_1)\right]$ $x\left[0.90757\ a_p\rho_{av1} - 30341\ .04\,a_\mu\mu_{av1} - 0.37564 + 4.04016\left[\{0.55 + 41.7215\right.\right.$ $x\ (a_L d_d)^{0.80043}\}\{0.713 + 3.741\ (a_L H_3)^{-1.23458}\}\{3.11\exp(0.15\,a_v v_{av3}) - 3.13\}$ $x\ \exp\left[\{5.3759\ \exp(-0.2092\ a_L H_3)\}\ell n\{0.3719\ \exp(0.0019055\ a_L d_3) + 0.55\}\right]\left.\left.\right]\right]$ It is obvious that the above equation cannot be used independently in an excel sheet to estimate rain zone transfer co-efficient because there are parameters like viscosity, sauter mean diameter, Schmidt no., humidity ratio, air pressure and temp, etc that need to be calculated, again in an iterative manner, before using this equation. Hence, no fixed percentages can be

Noted

				indicated for rain zone transfer co-efficient.	
2.	This calculation shall be revised and confirmed based on the actual Civil GA drawing	This is a negligible value compared to the gross fill area available. This value is shown just for information and present the process of area calculation. The grid size is fixed at 4.5 m x 4.5 m as shown in the GA drawing. This is an input to civil and any civil details from civil GA will not be an input to thermal/mechanical. Hence, the thermal calculations presented will not change at any stage.	Please confirm that obstruction of columns will not affect significantly the performance of the Cooling tower.	It is already confirmed that this is a negligible value. Hence, there will be no change in thermal design due to civil designs.	Noted
3.	Please indicate formulae for pressure drops	Kindly note that the KaV/L and pressure drop calculations are confidential.	We understand KaV/L values are confidential. However, pressure drop calculations are provided by other cooling tower suppliers. Please indicate the formulas for the same.	Pressure drops can be calculated only after establishing KaV/L. This means that when KaV/L is considered confidential, the pressure drops also become confidential as these are a consequence of KaV/L. However, as explained at point no.1 above, the pressure drop equations cannot be used independently in an excel sheet for results as the formulae involve many other parameters that need be estimated first in an iterative manner. For example, the pressure drop in the rain zone is calculated using the formula,	Noted

				$$K_{rzfi} = 3a_v v_{w3}(H_3/d_d)\left[0.2246 - 0.31467a_\rho \rho_{av1} + 5263.04a_\mu \mu_{av1}\right.$$ $$+0.775526\{1.4824163\exp(71.52a_L d_d) - 0.91\}$$ $$\text{x}\ \{0.39064\exp(0.010912a_L d_3) - 0.17\}\left\{2.0892(a_v v_{av3})^{-1.3944} + 0.14\right\}$$ $$\text{x}\ \exp\left[\{0.8449\ell\text{n}(a_L d_3/2) - 2.312\}\{0.3724\ell\text{n}(a_v v_{av3}) + 0.7263\}\right.$$ $$\left.\left.\text{x}\ \ell\text{n}\left\{206.757(a_L H_3)^{-2.8344} + 0.43\right\}\right]\right](\rho_{av15}/\rho_{av1})(m_{av1}/m_{av15})^2\left(4A_{fr}/\pi d_3^2\right)^2$$ The very same properties of air and water used in the equation for rain zone transfer co-efficient are involved here and these can be estimated only in an iterative manner in the program. Hence, no formulae for pressure drop calculations can be furnished as these are as confidential as transfer co-efficient.

1	**General**						
1.1	**Design Duty Parameters**						
	Circulating Water Flow	90000	m^3/hr				
	HWT	42.5	^oC				
	CWT	33	^oC				
	Design WBT	28	^oC				
	Relative Humidity	45	%				
	Range	9.5	^oC				
	Approach	5	^oC				
	Basin Kerb above Max. WL	300	mm				
	Site Elevation above MSL for thermal design	0	m				
	Ambient Pressure	101325	N/m^2				
	Salinity	0	ppm				
1.2	**Tower Sizing Data**						
	Type of Fill	**PVC SPLASH BAR**					
	Fill Height (total hanging height)	5.2	m				
	Fill Height above Air Inlet	4.8					
	Top of Air Inlet above basin kerb	9.7	m				
	Bottom of Fill above Sill level	9.7	m				
	Top of Fill above Sill	14.5	m				
	Bottom of distribution Pipe (BOP) above Fill	0.7	m				
	Static Head up to BOP w.r.t Sill	15.2	mWC				
	Center line Dia.of tower at basin Sill level	145.67	m				
	Internal Diameter of tower at basin sill level	144.67	m				
	Internal Diameter at top of Fill level	135.97	m				
	Gross Fill Area	14520.316	m^2 ==========>>	**A**			
	Length of each HW Duct	123.5	m approx.				
	Outer Width of each HW Duct	3.1	m approx.				
	Area of HW Ducts	765.5690513	m^2 ==========>>	**B**			
	Column Obstructions	179.5	m^2 ==========>>	**C**			
	Net Fill Area Available	13575.247	m^2 ==========>>	**(A-B-C)**			
	Effective Fill Area considered in design	13075.410	m^2				
	Water Loading Rate	6.883	$m^3/hr/m^2$				
	Liquid to Gas Ratio	2					

1.2.1	**Basin Sizing Calculations**						
	Max. Water Level	RL 81.1	m				
	Min. Water Level	RL 80.5	m				
	Difference between Max. & Min. Water Levels	0.6	m ==========>>	**d**			
	Storage Capacity required between Max. & Min. Water Levels	6 minutes hold up					
	6 minutes' hold up water volume (= 90,000 m3/hr/60*6)	9000	m3 ==========>>	**V**			
	Basin Area required for 6 minutes' hold up capacity	15000	m2 ==========>>	**(V/d)**			
	Basin Diameter Required	138.198	m	**(SQRT((V/d)*4/PI)**			
	Basin Diameter Required < Basin Diameter Provided		Hence, size is conservative				
2	**Thermal Calculations**						
	Inlet air properties						
	Design WBT	28	°C				
	Relative Humidity	45	%				
	DBT	38.53	°C				
	Abs. Humidity	0.0197	kg/kg				
	Dry Air Density	1.0902	kg/m^3				
	Air-Vapour mixture Density	1.1192	kg/m^3				
	Enthalpy	21.441	kCal/kg				
2.1	**KaV/L Calculations**						
	KaV/L as per Tchebycheff Method	1.95	Calculations enclosed				
	KaV/L provided	1.95					
2.1.1	**Exit Air Properties**						
	WBT	40.74	°C				
	Relative Humidity	100	%				
	DBT	40.74	°C				
	Abs. Humidity	0.0513	kg/kg				
	Dry Air Density	1.0380	kg/m^3				
	Air-Vapour mixture Density	1.0908	kg/m^3				
	Enthalpy	41.484	kCal/kg				
	Enthalpy Gain	20.043	kCal/kg				
	Density Difference ($\Delta \rho$)	0.0284	kg/m^3				
	Average of Air-Vapour mixture Densities	1.105	kg/m^3				
	Dry Air Flow through the tower	12500.08	kg/s				

2.2	**Draught Calculations**						
	Draught Losses						
	Air Inlet + Rain Zone + Columns & Beams below Fill	2.3130	mmWC				
	Fill + Other Phenomenon	2.3410	mmWC				
	Distribution + D/E	0.2931	mmWC				
	Throat+Other Phenomenon	0.2687	mmWC				
	Total of draught losses	5.2157	mmWC				
	Draught Height Required (Δpd/Δ)	183.653	m				
	Tower Height Required (Draught Height + 0.5*Fill Height + Air Inlet)	**195.75**	**m**				
	Tower Height Provided	**198.19**	**m**				
2.3	**Check for Heat Balance**						
	Dry Air Flow, G	45000288	kg/hr				
	Evaporation Loss	1422009.101	kg/hr				
	Specific Heat of Water	1	kCal/kg/^{o}C				
	Heat Lost by circulating Water	855000000	kCal/hr				
	Heat of Evaporated Water	46926300.33	kCal/hr				
	Total Heat Lost by Water	**901926300**	kCal/hr				
	Heat Gain by Air	20.043	kCal/kg				
	Total Heat Gain by Air	**901940772**	kCal/hr				
3	**Draught Loss Calculations**						
3.1	**Loss through Inlet + Rain Zone + Other Phenomena below Fill**						
	G	kg/s	12500.08				
	Abs. Humidity at Inlet	kg/kg	0.0197				
	Air-Vapour mixture Density at Inlet	kg/m^3	1.1192				
	Inside Base Diameter	m	144.67				
	Air Inlet Height	m	9.7				
	Shell Angle (average)	deg.	16.7				
	Air Inlet Area	m^2	4319.912				
	Air Flow Rate through inlet	m^3/s	11388.7880				
	Air Velocity through inlet	m/s	2.6363				
	Effective rain area	m^2	13575.2472				
	Air Velocity through Rain Zone	m/s	0.8389				
	Draught Loss through Inlet + Rain Zone + Other Phenomena below Fill	**mmWC**	**2.3130**				

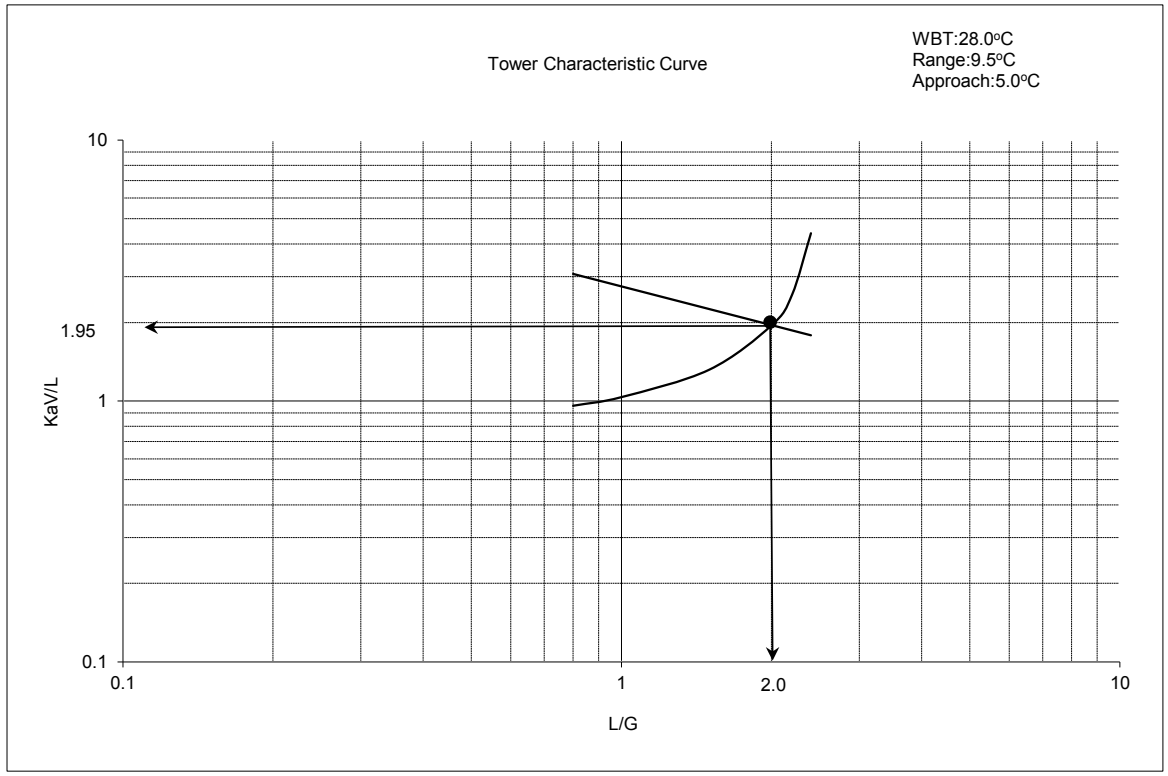
3.2	**Loss through Fill**						
	Gross Fill Height	m	5.2				
	Average Abs. Humidity	kg/kg	0.0355				
	Average Air-Vapour mixture Density through Fill	kg/m^3	1.105				
	G	kg/s	12500.08				
	Air Flow Rate through Fill	m^3/s	11713.876				
	Effective Fill Area	m^2	13075.410				
	Average Air Velocity through Fill	m/s	0.896				
	Draught Loss through Fill	**mmWC**	**2.3410**				
3.3	**Loss through Distribution System + Drift Eliminator Packing (DDE)**						
	G	kg/s	12500.08				
	Abs. Humidity at Exit	kg/kg	0.0513				
	Air-Vapour mixture density at exit	kg/m^3	1.0908				
	Diameter at Distribution	m	135.550				
	Gross Area at Distribution	m^2	14430.746				
	Net Area at Distribution	m^2	9754.48				
	Effective Area considered in design	m^2	9754.48				
	Air flow rate through DDE	m^3/s	12047.42767				
	Air Velocity through DDE	m/s	1.2351				
	Draught Loss through DDE	mmWC	**0.2931**				
3.4	**Loss through Throat/Neck + Expansion**						
	G	kg/s	12500.08				
	Abs. Humidity at Exit	kg/kg	0.0513				
	Air mixture/vapour density	kg/m^3	1.0908				
	Throat Diameter	m	85.27				
	Throat Area	m^2	5710.609				
	Air flow through throat	m^3/s	12047.42767				
	Air velocity through Throat/Neck	m/s	2.110				
	Draught Loss across Throat + Expansion	**mmWC**	**0.2687**				

4	**KaV/L Calculations (Chebyshev / Tchebycheff Method)**						
	L/G	2					
	Range	9.5	°C				
	WBT	28	°C				
	h1	21.564	kCal/kg				
	h2 = h1+L/G*Range*Cp	40.564	kCal/kg				
T °C		T °K	hw, kCal/kg	ha, kCal/kg		hw-ha	1/(hw-ha)
33	T2	306.15		h1	21.564		
33.95	T2+0.1*Range	307.1	29.40722517	h1+0.1*L/G*Range*Cp	23.46437	5.9428571	0.1682692
36.8	T2+0.4*Range	309.95	33.99825076	h1+0.4*L/G*Range*Cp	29.16437	4.8338827	0.206873
38.7	T1-0.4*Range	311.85	37.42191551	h2-0.4*L/G*Range*Cp	32.96437	4.4575475	0.2243386
41.55	T-0.1*Range	314.7	43.18375552	h2-0.1*L/G*Range*Cp	38.66437	4.5193875	0.2212689
42.5	T1	315.65		h2	40.564		
	KaV/L = Range/4*Σ1/(hw-ha)*Cp					Σ1/(Ew-Ea)	0.8207498
	KaV/L Required =	1.95					
	KaV/L Provided =	1.95					
5	**Duty Coefficient (D_t)**						
	D_t=	A√H/(C√C)					
	where	A =	16437.91931	m^2 (area at sill)			
			176845.7111	ft^2			
		H =	198.19	m (tower height above sill)			
			650.0632	ft			
		C =	3.6829798	Performance co-efficient from S.No.6 below			
	Therefore, Dt=	637930					
6	**Performance Coefficient (C)**						
	C=	(1/(KaV/L) + L/(2G))*G/L*$N^{1/3}$					
	We have	KaV/L =	1.95				
		L/G =	2				
		N =	Pd * 2g/(ρ·v^2)	No. of velocity heads			
	where	Pd =	5.2157	mmWC (tower pressure drop)			
		ρ =	1.105	air-vapour density in fill section			
		v =	0.896	afflux air velocity in fill section			
	Therefore, N=	115.39					
	Hence, C=	3.68					
7	**Draught Factor (F)**						
	F=	Δρ/(1.64*10^-8*Δh)					
	We have	Δρ =	0.0284	kg/m^3 (difference in air-vapour mixture density at inlet and			
			0.001775	lb/ft^3			
		Δh =	20.043	kcal/kg (difference in enthalpy at inlet and outlet)			
			36.0774	BTU/lb			
	Therefore, F=	3000					

1	**Pumping Head Calculations**						
			Header Pipe	**Riser Pipe**			
	Inlet Pipe Diameter	m	3.95	3.4			
	Flow per inlet pipe	m^3/hr	90000	45000			
		m^2	12.254	9.079			
	Velocity of Flow	m/s	2.040	1.377			
1.1	**Friction Loss Through Pipes [as per Hazen-Willam Method]**						
	D[m]	V[m/s]	C (for new pipe)	*S*	*L[m]*		P_d[m]
	3.95	2.040	120	0.000724737	5		0.0036237
	3.4	1.377	120	0.000416742	80		0.0333393
	Total Friction Loss Through Staright Pipes						**0.036963**
1.2	**Head Loss Through Fittings**						
1.2.1	**Welded Elbows [theeta=90, K=20f]**						
	Flow [m3/s]	Dia. [m]	Vel [m/s]	Vh [mmWC]	f	K	Pd
	90000	3.95	2.040	0.212135264	0.0094	0.18738464	0.0397509
	45000	3.4	1.377	0.096610781	0.0096	0.19219992	0.0185686
	45000	3.4	1.377	0.096610781	0.0096	0.19219992	0.0185686
							0.0768881
1.2.2	**TEE [K=60f]**						
	45000	3.4	1.377	0.096610781	0.0096	0.57659976	**0.0557058**
1.3	**Butterfly Vlaves [20f)**						
	45000	3.4	1.377	0.096610781	0.0096	0.19219992	**0.0185686**
		Exit Dia.	Vel [m/s]	Vh [mmWC}			
1.4	**Expansion Loss**	3.8	1.102	0.015425581			**0.0154256**

1.5	**Discharge Loss**						
	Discharge Velocity	m/s	1.102				
	Discharge Loss	mWC	**0.0619**				
1.6	**Friction Loss through RCC Duct**						
	Water Flow per duct (F)	m^3/hr	45000				
	Duct Depth	m	3.5				
	Duct Width	m	2.5				
	Duct Wetted Area (WA)	m^2	8.75				
	Duct Perimeter (P)	m	12				
	Hydraulic Radius (R = WA/P)		0.729				
	Flow Velocity through Duct (V = F/WA)	m/s	1.429				
	Slope S = $(n * V / R^{2/3})^2$, n = 0.015	per m	0.000699655				
	Duct Length	m	123.5				
	Friction Loss through RCC Duct	mWC	**0.086393**				
1.7	**Head Loss due to sudden turns and contraction**						
	Turning into Sec. RCC Channel from Main. RCC Channel	mWC	**0.0312**				
	Second turn into PVC Pipe from RCC Duct	mWC	**0.0312**				
	Sudden Contraction (Duct to Pipe)	mWC	**0.0374**				
1.8	**Friction loss through PVC distribution piping (longest pipe considered)**	mWC	**0.0755**				

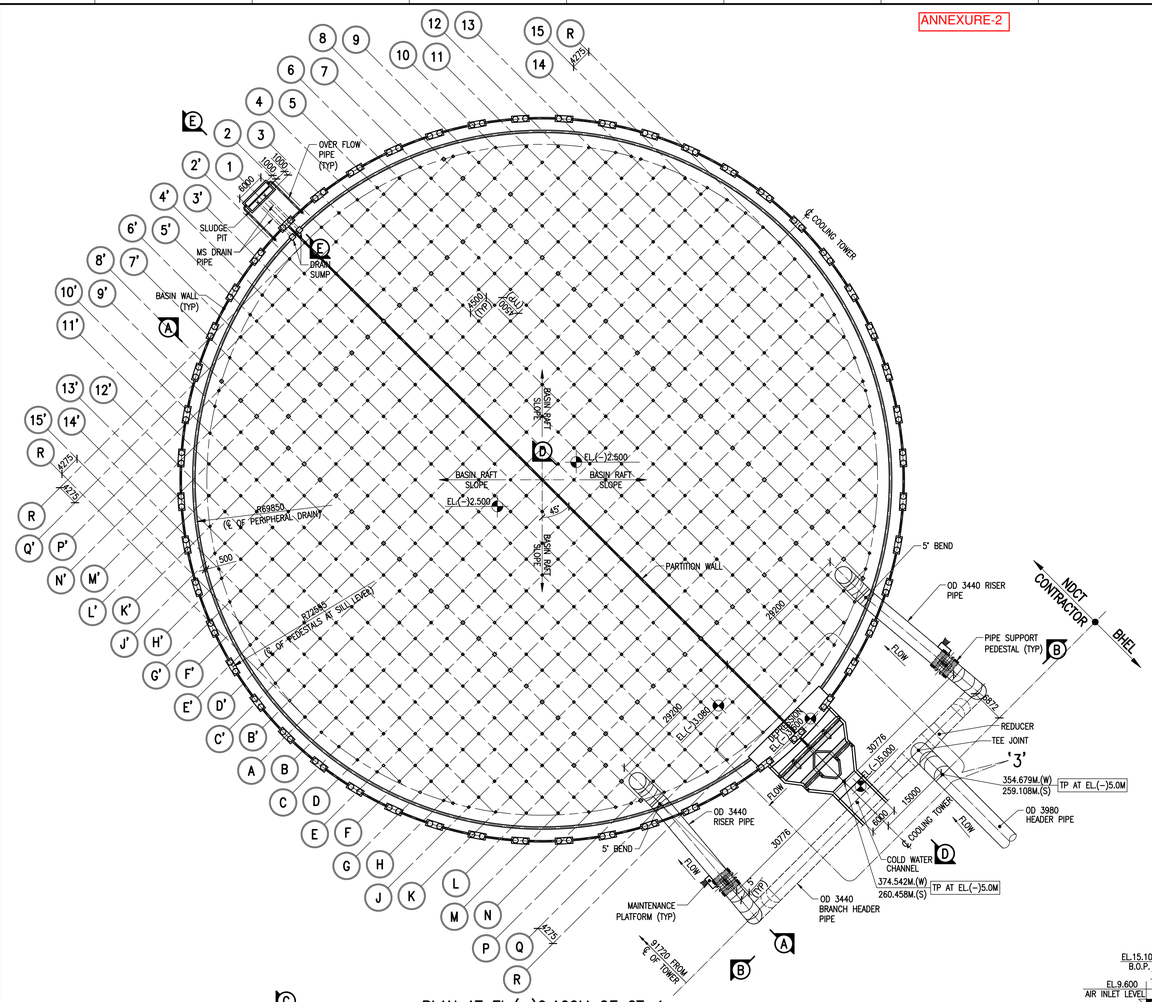
1.9	**Sum of Friction + Head Losses from S.No. 1.1 to 1.8**	mWC	**0.5272**				
	Friction Losses with 10% Margin	mWC	**0.5799**	**==========> SFH**			
2	**Spray Nozzle Head**	mWC	**0.5**	**==========> SNH**			
3	**Sum of SFH + SNH**	mWC	**1.0799**				
4	**Static Head**						
	Sill Level above FGL	1.4	m				
	Air Inlet Height above Sill	9.7	m				
	Fill Height above Air Inlet	4.8	m				
	Top of Fill to bottom of distribution Pipe	0.7	m				
	Total Static Head above FGL	**16.6**	m				
5	**Total Head Utilized**						
	Friction/Head Losses + Static Head	**17.680**	mWC				
	Total Head Utilized is	≈	Total Head Available				


Tower Characteristic Curve
WBT:28.0ºC
Range:9.5ºC
Approach:5.0ºC
10
1.95
1
0.1
KaV/L
0.1
1
2.0
10
L/G

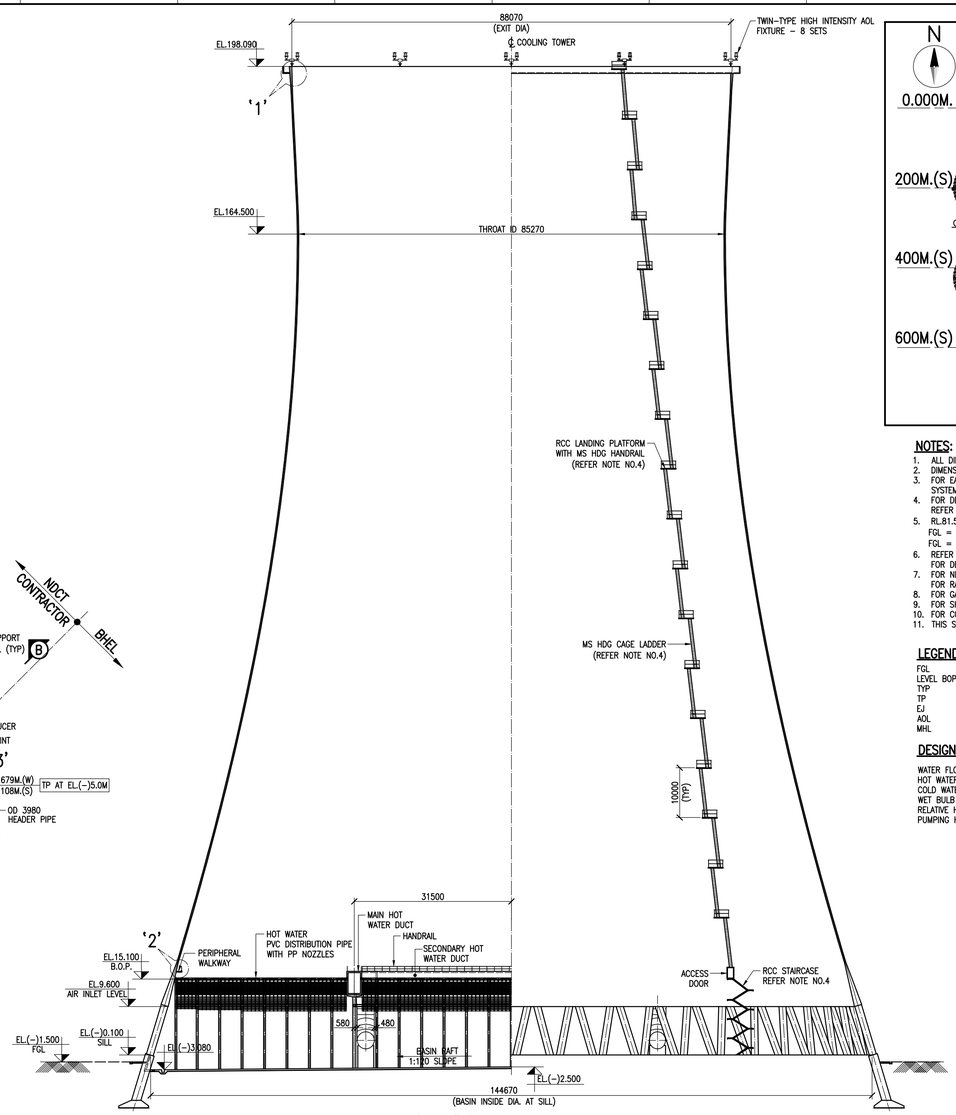
NOTE: ALL ELEVATIONS GIVEN HERE ARE CONSIDERING SILL LEVEL = EL 0.00 M, WHEREAS IN THE GA DRWG IT IS (-) 0.1 M AS PER SPECIFICATIONS

SL. NO.	PARAMETERS	VALUE	UNIT OF MEASUREMENT
1	BASIN DIA. AT SILL LEVEL (ID)	144.67	M
2	TOTAL NDCT HEIGHT FROM SILL TOP	198.19	M
3	HEIGHT OF AIR INLET FROM SILL TOP	9.7	M
4	HEIGHT OF TOP OF FILL FROM SILL TOP	14.5	M
5	HEIGHT OF BOTTOM OF FILL FROM SILL TOP	9.4	M
6	L/G RATIO	2.0	
7	EVAPORATION LOSS	1422.009	M^3/HR
8	INLET AIR ENTHALPY	21.441	KCAL/KG
9	OUTLET AIR ENTHALPY	41.484	KCAL/KG
10	AVG. AIR-VAPOUR MIX. DENSITY AT	1.105	KG/M^3
11	AVG. AIR-VAPOUR MIX. DENSITY AT	--	KG/M^3
12	DIA. AT TOP OF FILL LEVEL	135.97	M
13	GROSS FILL AREA	14520.316	M^2
14	AREA OF HOT WATER DUCTS	765.569	M^2
15	COLUMN/BEAM OBSTRUCTION AREA	179.5	M^2
16	NET FILL AREA AVAILABLE	13575.247	M^2
17	AVG. AIR VELOCITY AT TOWER INLET	2.636	M/S
18	AVG. AIR VELOCITY IN FILL SECTION	0.896	M/S
19	AVG. AIR-VAPOUR DENSITY IN FILL SECTION	1.105	KG/M^3
20	LOSSES IN NUMBER OF VELOCITY HEAD AT AIR INLET	REFER	NO. OF VEL. HEAD
21	LOSSES IN NUMBER OF VELOCITY HEAD AT RAIN ZONE	DETAILED	NO. OF VEL. HEAD
22	LOSSES IN NUMBER OF VELOCITY HEAD AT FILL ZONE	THERMAL	NO. OF VEL. HEAD
23	LOSSES IN NUMBER OF VELOCITY HEAD THROUGH WATER DISTRIBUTION /BEAMS /COLUMNS	CALCULATIONS	NO. OF VEL. HEAD
24	LOSSES IN NUMBER OF VELOCITY HEAD THROUGH DRIFT ELIMINATORS	ENCLOSED	NO. OF VEL. HEAD
25	LOSSES IN NUMBER OF VELOCITY HEAD AT AIR EXIT	WITH THESE	NO. OF VEL. HEAD
26	LOSSES IN NUMBER OF VELOCITY HEAD THROUGH THROAT/NECK	DATA SHEETS	NO. OF VEL. HEAD
27	TOTAL TOWER PRESSURE DROP	5.2157	MMWC

ANNEXURE-2

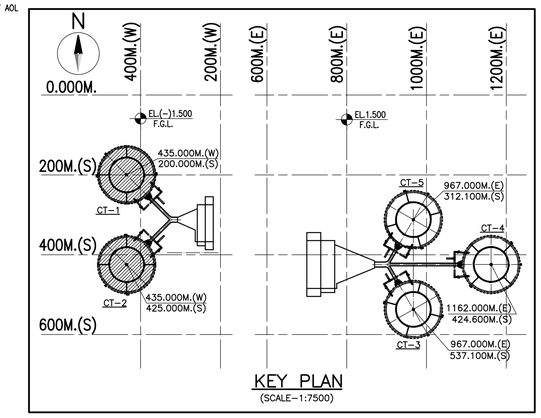


PLAN AT EL.(−)0.100M OF CT−1
(SCALE−1:600)



HALF SECTION OF CT1 & CT2 (UNIT#1)
(SCALE−1:600)

HALF ELEVATION OF CT1 & CT2 (UNIT#1)
(SCALE−1:600)



KEY PLAN
(SCALE−1:7500)

NOTES:

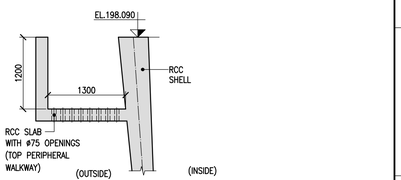
1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METER UNLESS OTHERWISE SPECIFIED.
2. DIMENSIONS ARE NOT TO BE SCALED. ONLY WRITTEN DIMENSIONS ARE TO BE FOLLOWED.
3. FOR EARTHING & LIGHTNING PROTECTION DETAILS REFER DRAWING NO. PE−V1−417−165−N055 AND FOR AOLs SYSTEM DETAILS REFER DRAWING NO. PE−V1−417−165−N065
4. FOR DETAILS OF STAIRCASE REFER DRAWING NO. PE−V1−417−165−N023 & FOR DETAILS OF CAGE LADDER REFER DRAWING NO. PE−V1−417−165−N045A
5. RL.81.500 CORRESPONDS TO EL.(−)0.000 OF POWER HOUSE BUILDING
   FGL = EL.(−)1.500 CORRESPONDS TO RL.80.000. IN THE COOLING TOWER AREA FOR CT#1 & CT#2
   FGL = EL.(+)1.500 CORRESPONDS TO RL.83.000. IN THE COOLING TOWER AREA FOR CT#3 , CT#4 & CT#5
6. REFER DRAWING NO.PE−V1−417−165−N059 (GENERAL ARRANGEMENT OF EXTERNAL HW DISTRIBUTION SYSTEM) FOR DETAILS OF PAINTING FOR PROTECTION OF INTERNAL & EXTERNAL SURFACES OF PIPING.
7. FOR NDCT FOUNDATION & PEDESTAL DETAILS REFER DRG.NO.PE−V1−417−165−N034 & FOR RAKER COLUMN DETAILS REFER DRG.NO.PE−V1−417−165−N036.
8. FOR GA OF FILL SUPPORTING STRUCTURE REFER DRG.NO.PE−V1−417−165−N026.
9. FOR SHELL PROFILE REFER DRG.NO.PE−V1−417−165−N038.
10. FOR COLD WATER OUTLET DETAILS REFER DRG.NO.PE−V1−417−165−N016.
11. THIS SHEET SHOULD BE READ IN CONJUNCTION WITH SHEETS 2,3,4,5 & 6 OF THIS DRAWING.

LEGENDS

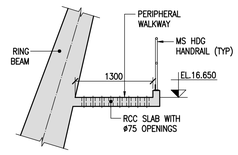
FGL	−	FINISH GROUND
LEVEL BOP	−	BOTTOM OF PIPE
TYP	−	TYPICAL
TP	−	TERMINAL POINT
EJ	−	EXPANSION JOINT
AOL	−	AVIATION OBSTRUCTION LIGHT
MHL	−	MAIN HEADER LEVEL

DESIGN DUTY PARAMETERS

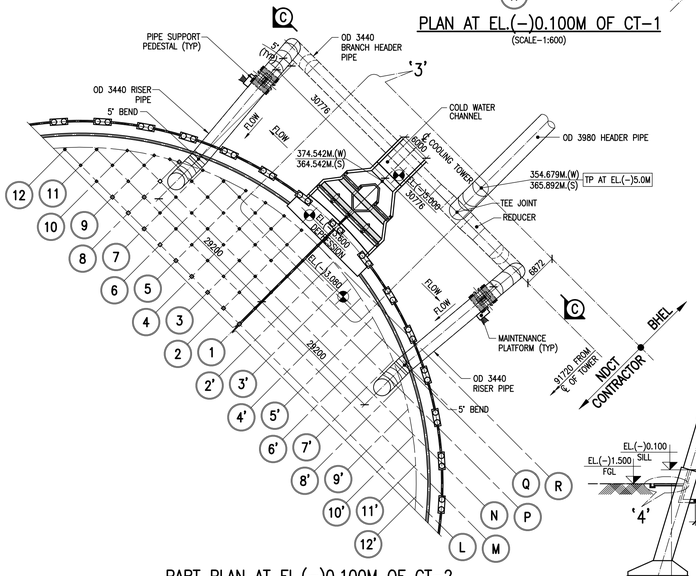
WATER FLOW	: 90000 M^3/HR
HOT WATER TEMPERATURE	: 42.5°C
COLD WATER TEMPERATURE	: 33°C
WET BULB TEMP.	: 28°C
RELATIVE HUMIDITY	: 45%
PUMPING HEAD	: 16.3 MWC w.r.t BASIN SILL



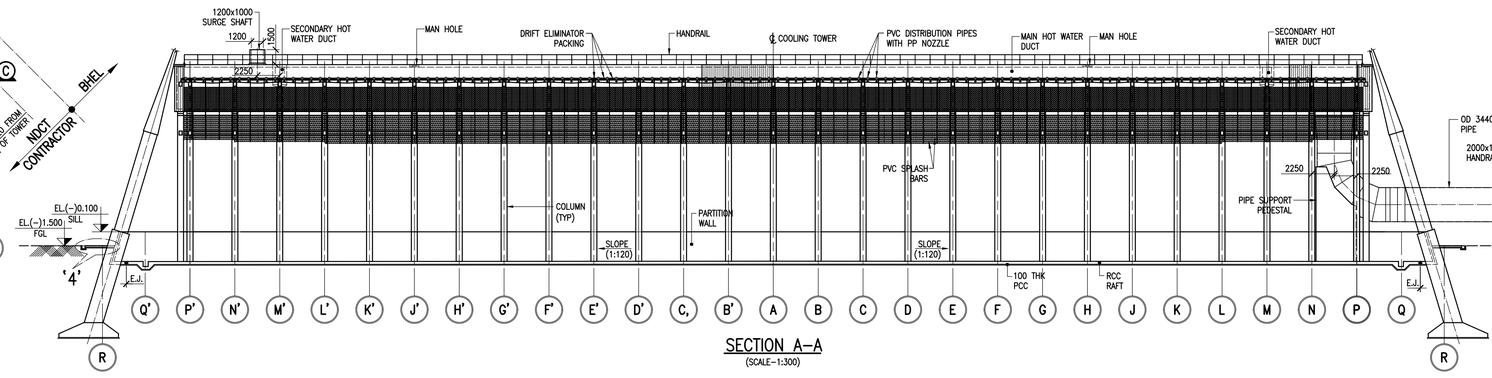
DETAIL−'1'
(SCALE−1:50)



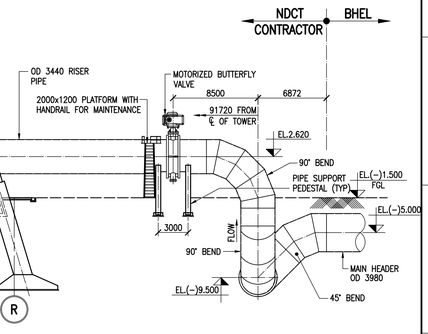
DETAIL−'2'
(SCALE−1:50)



PART PLAN AT EL.(−)0.100M OF CT−2
(SCALE−1:600)



SECTION A−A
(SCALE−1:300)



REV. NO.	DATE	DESCRIPTION	DRAWN
2	01/12/18	BASED ON TCE & TSGENCO COMMENTS Dt. 22/11/18	SCJ
1	10/08/18	BASED ON TCE COMMENTS Dt. 03/08/18	CDS
0	26/06/18	FOR APPROVAL	SHM

CUSTOMER: TELANGANA STATE POWER GENERATION CORPORATION LTD, TELANGANA INDIA

CONSULTANT: TATA CONSULTING ENGINEERS LIMITED, BANGALORE INDIA

EPC CONTRACTOR: BHARAT HEAVY ELECTRICALS LIMITED

NDCT CONSULTANT: SPECTRUM Techno Consultants Pvt Ltd, 401, Raikar Bhavan, Plot No. 9, Sector-17, Vashi, Navi Mumbai 400 705 India. Email : info@spectrumworld.net

PROJECT: 5x800 MW YADADRI THERMAL POWER STATION

DRAWN BY :	SHM
CHECKED BY	UNB
APPROVED BY	UKR
DATE	10/08/2018
SCALE	AS SHOWN

TITLE: GENERAL ARRANGEMENT OF NATURAL DRAUGHT COOLING TOWER (STAGE#1)

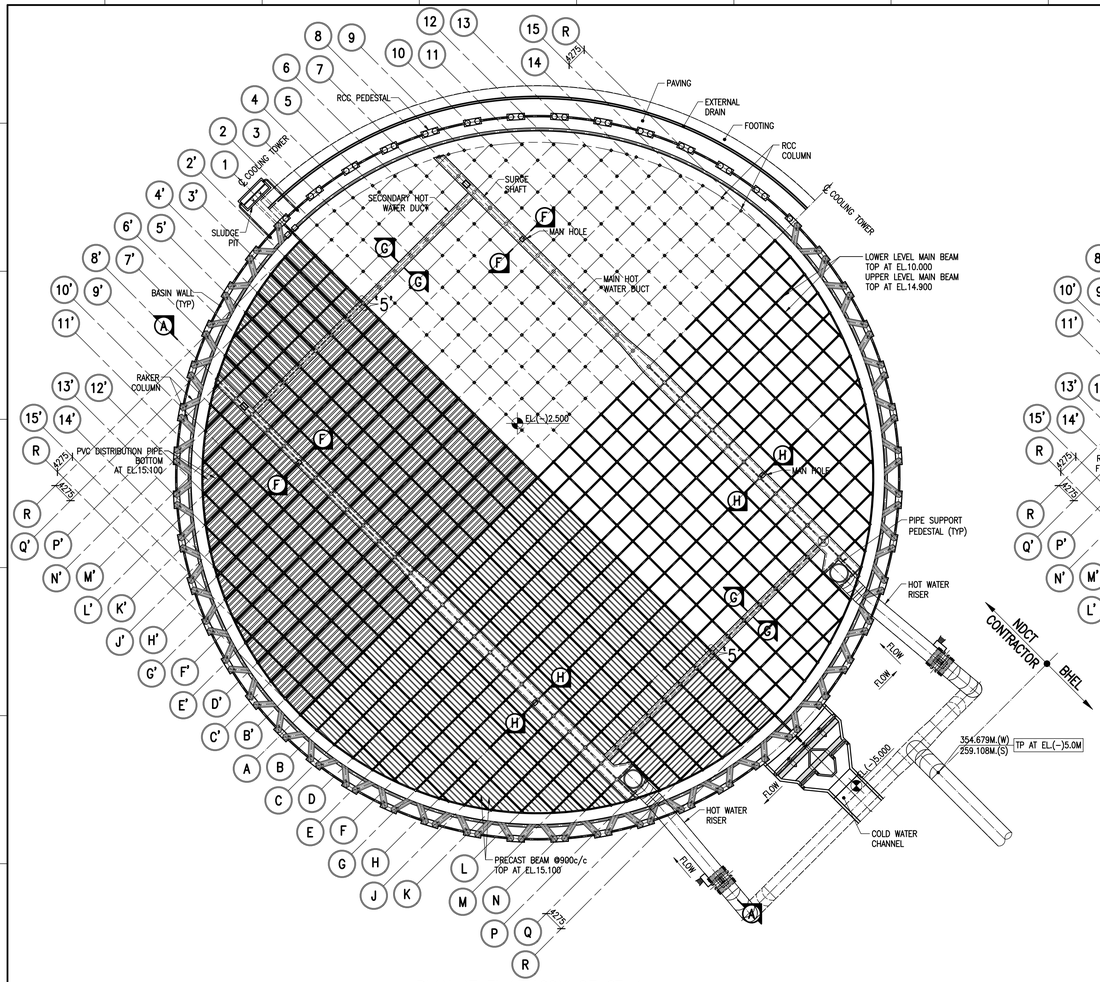
STCPL DRG.NO. 760-E-DD-101 REV.NO.

BHEL DRG.NO. PE-V1-417-165-N001 (SHEET 1 OF 6) 2

THIS DRAWING IS THE PROPERTY OF SPECTRUM Techno Consultants Pvt Ltd IT IS SUBJECT TO THEIR RECALL, AND MUST NOT BE LENT, COPIED OR REPRODUCED WITHOUT THEIR WRITTEN PERMISSION.

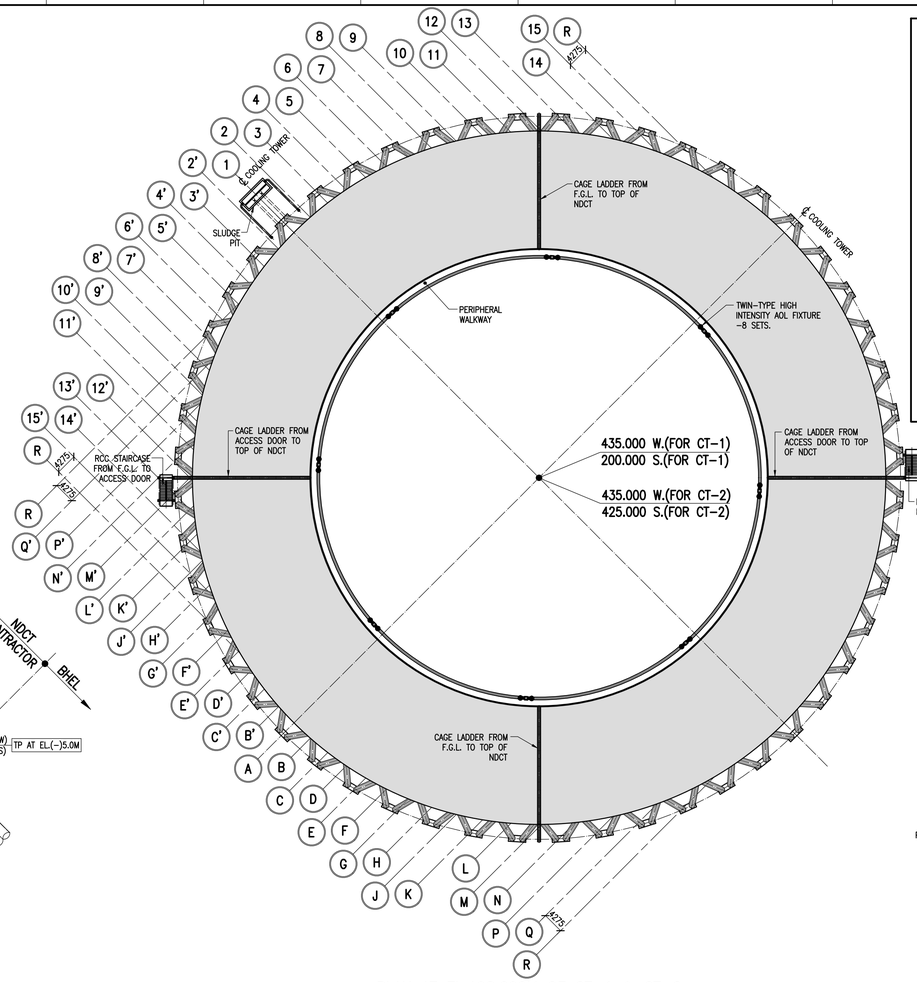
SHEET SIZE : A1

FILE NAME : X:\760-YADADRI\NDCT\WORKING\760-E-DD-101-R2 (GAD FOR NDCT 1 to 5).dwg



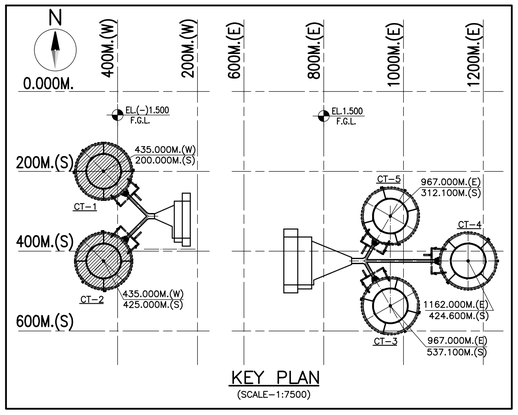
PLAN AT EL.15.100M OF CT-1

(SCALE-1:600)



PLAN AT EL.198.090M OF CT-1 & CT-2

(SCALE-1:600)

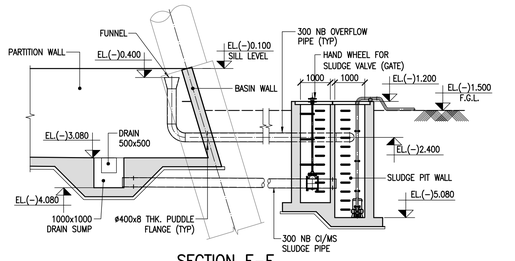


KEY PLAN

(SCALE-1:7500)

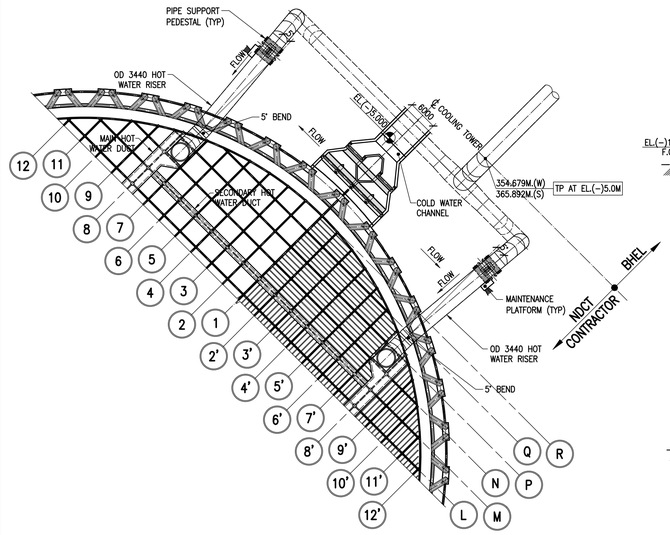
NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METER UNLESS OTHERWISE SPECIFIED.
2. DIMENSIONS ARE NOT TO BE SCALED. ONLY WRITTEN DIMENSIONS ARE TO BE FOLLOWED.
3. THIS SHEET SHOULD BE READ IN CONJUNCTION WITH SHEETS 1,3,4,5 & 6 OF THIS DRAWING.



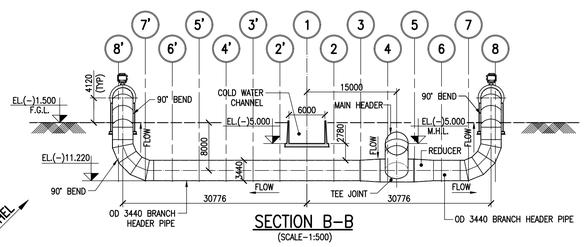
SECTION E-E

(SCALE-1:100)



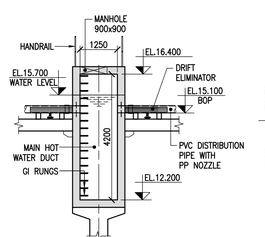
PART PLAN AT EL.15.100M OF CT-2

(SCALE-1:600)



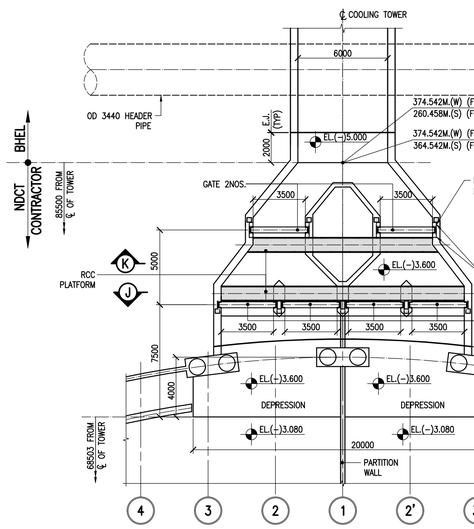
SECTION B-B

(SCALE-1:500)



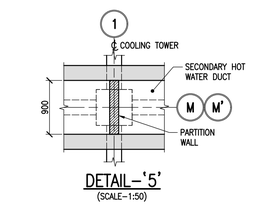
SECTION F-F

(SCALE-1:100)



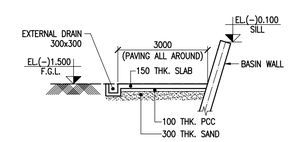
DETAIL-'3'

(SCALE-1:200)



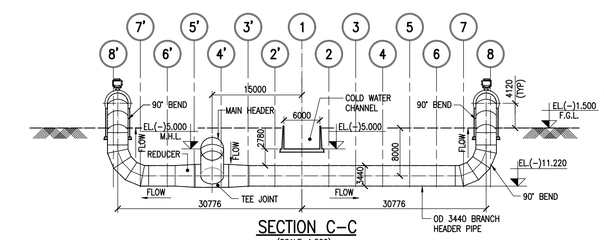
DETAIL-'5'

(SCALE-1:50)



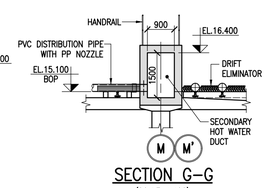
DETAIL-'4'

(SCALE-1:100)



SECTION C-C

(SCALE-1:500)



SECTION G-G

(SCALE-1:100)

REV. NO.	DATE	DESCRIPTION	DRAWN
2	01/12/18	BASED ON TCE & TSGENCO COMMENTS Dt. 22/11/18	SCJ
1	10/08/18	BASED ON TCE COMMENTS Dt. 03/08/18	CDS
0	26/06/18	FOR APPROVAL	SHM

CUSTOMER: TELANGANA STATE POWER GENERATION CORPORATION LTD, TELANGANA INDIA

CONSULTANT: TATA CONSULTING ENGINEERS LIMITED, BANGALORE INDIA

EPC CONTRACTOR: BHARAT HEAVY ELECTRICALS LIMITED

NDCT CONSULTANT: SPECTRUM Techno Consultants Pvt Ltd, 401, Raikar Bhavan, Plot No. 9, Sector-17, Vashi, Navi Mumbai 400 705, India. Email : info@spectrumworld.net

PROJECT: 5x800 MW YADADRI THERMAL POWER STATION

DRAWN BY :	SHM
CHECKED BY	UNB
APPROVED BY	UKR
DATE	10/08/2018
SCALE	AS SHOWN

TITLE: GENERAL ARRANGEMENT OF NATURAL DRAUGHT COOLING TOWER (STAGE#1)

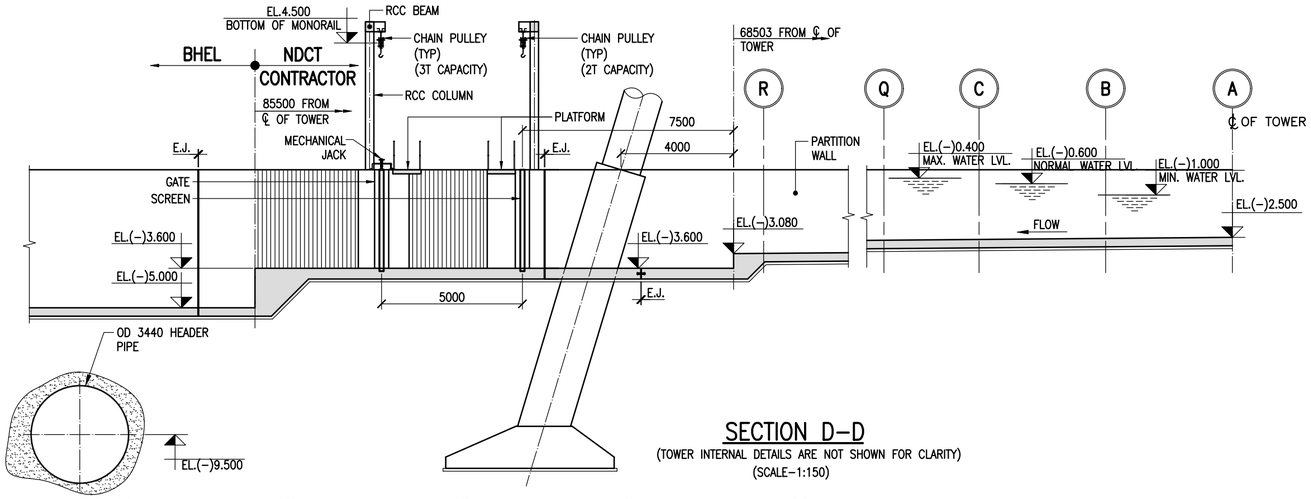
STCPL DRG.NO. 760-E-DD-101 REV.NO. 2

BHEL DRG.NO. PE-V1-417-165-N001 (SHEET 2 OF 6)

THIS DRAWING IS THE PROPERTY OF SPECTRUM Techno Consultants Pvt Ltd IT IS SUBJECT TO THEIR RECALL AND MUST NOT BE LENT, COPIED OR REPRODUCED WITHOUT THEIR WRITTEN PERMISSION.

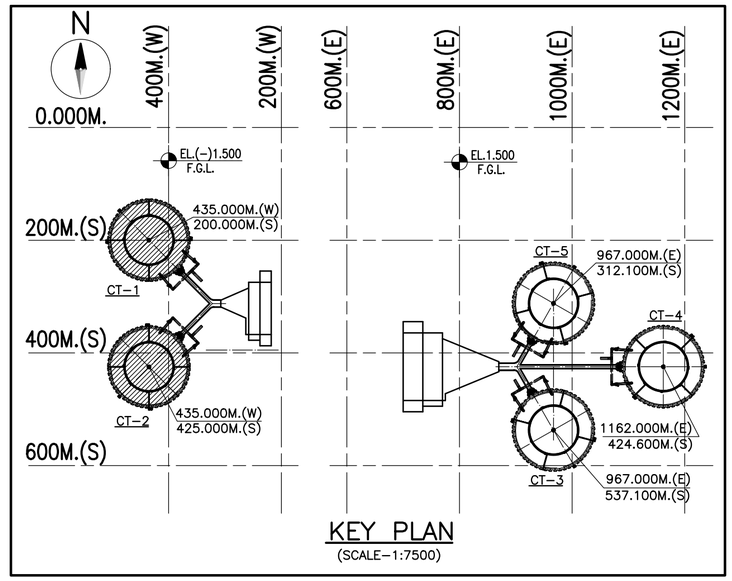
SHEET SIZE : A1

FILE NAME : X:\760-YADADRI\NDCT\WORKING\760-E-DD-101-R2 (GAD FOR NDCT -1 to 5).dwg



SECTION D–D

(TOWER INTERNAL DETAILS ARE NOT SHOWN FOR CLARITY)
(SCALE–1:150)

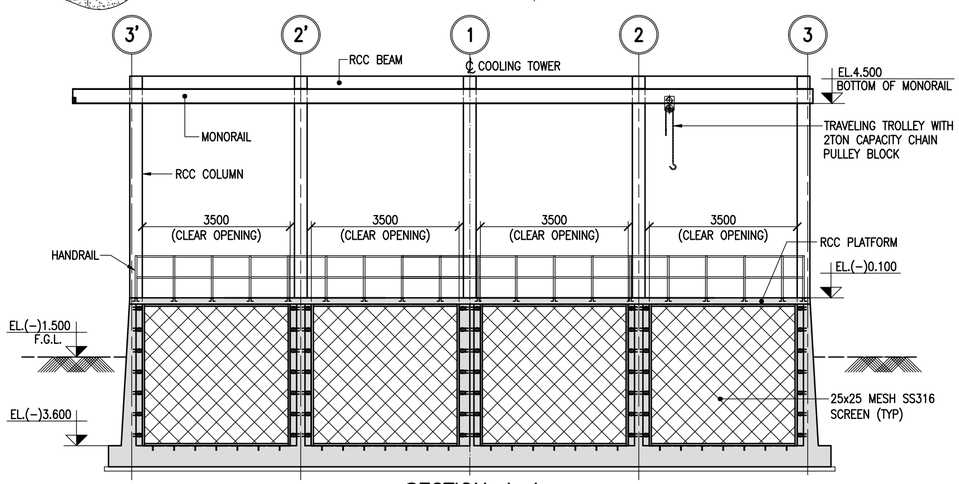


KEY PLAN

(SCALE–1:7500)

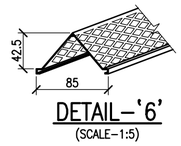
NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METER UNLESS OTHERWISE SPECIFIED.
2. DIMENSIONS ARE NOT TO BE SCALED. ONLY WRITTEN DIMENSIONS ARE TO BE FOLLOWED.
3. THIS SHEET SHOULD BE READ IN CONJUNCTION WITH SHEETS 1,2,4,5 & 6 OF THIS DRAWING.



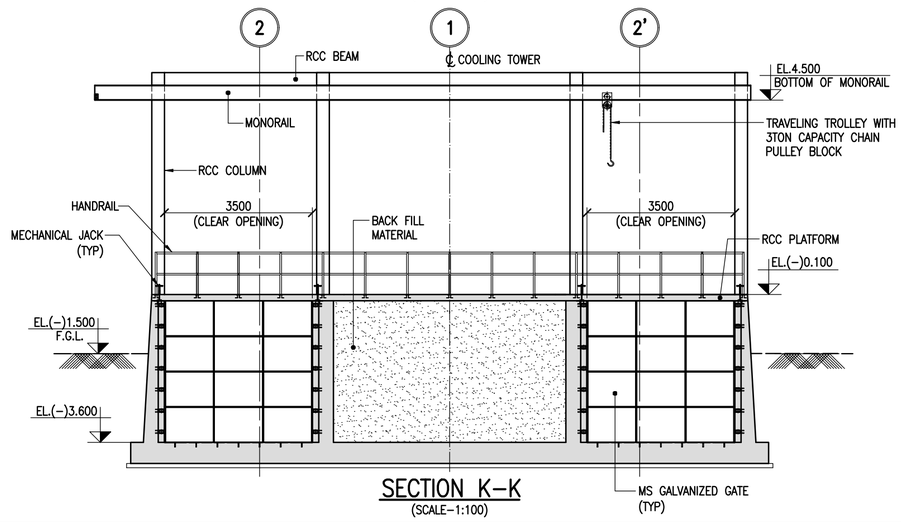
SECTION J–J

(SCALE–1:100)



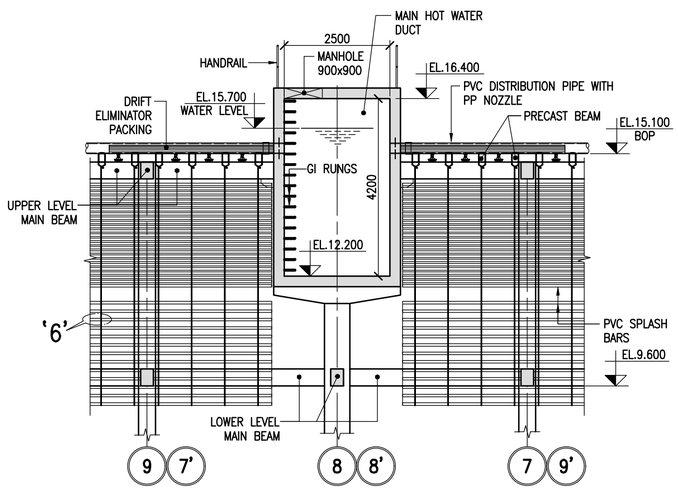
DETAIL–'6'

(SCALE–1:5)



SECTION K–K

(SCALE–1:100)



SECTION H–H

(SCALE–1:100)

REV. NO.	DATE	DESCRIPTION	DRAWN
2	01/12/18	BASED ON TCE & TSGENCO COMMENTS Dt. 22/11/18	SCJ
1	10/08/18	BASED ON TCE COMMENTS Dt. 03/08/18	CDS
0	26/06/18	FOR APPROVAL	SHM

CUSTOMER: TELANGANA STATE POWER GENERATION CORPORATION LTD, TELANGANA INDIA

CONSULTANT: TATA CONSULTING ENGINEERS LIMITED, BANGALORE INDIA

EPC CONTRACTOR: BHARAT HEAVY ELECTRICALS LIMITED

NDCT CONSULTANT: SPECTRUM Techno Consultants Pvt Ltd
401, Raikar Bhavan, Plot No. 9, Sector-17, Vashi, Navi Mumbai 400 705
India. Email : info@spectrumworld.net

5x800 MW YADADRI THERMAL POWER STATION

DRAWN BY :	SHM
CHECKED BY	UNB
APPROVED BY	UKR
DATE	10/08/2018
SCALE	AS SHOWN

TITLE: GENERAL ARRANGEMENT OF NATURAL DRAUGHT COOLING TOWER (STAGE#1)

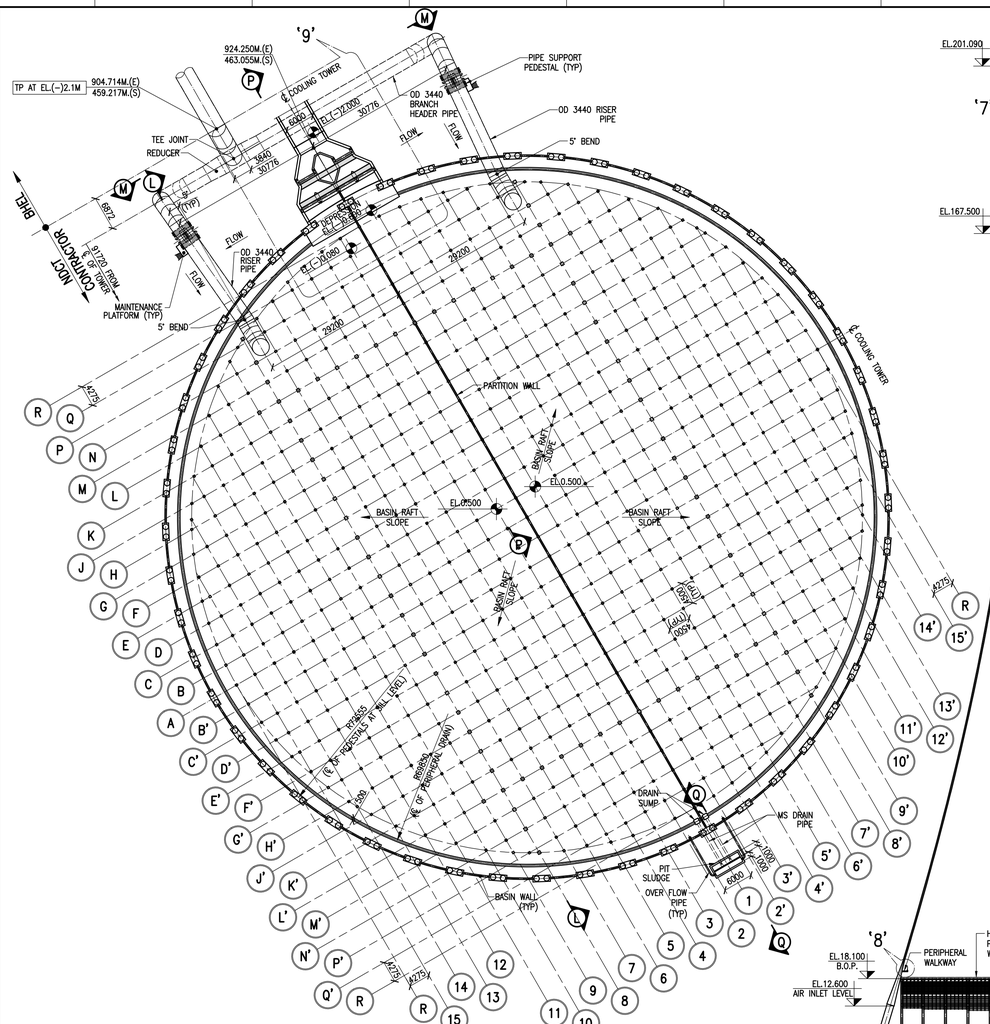
STCPL DRG.NO. 760-E-DD-101 — REV.NO. 2

BHEL DRG.NO. PE-V1-417-165-N001 (SHEET 3 OF 6)

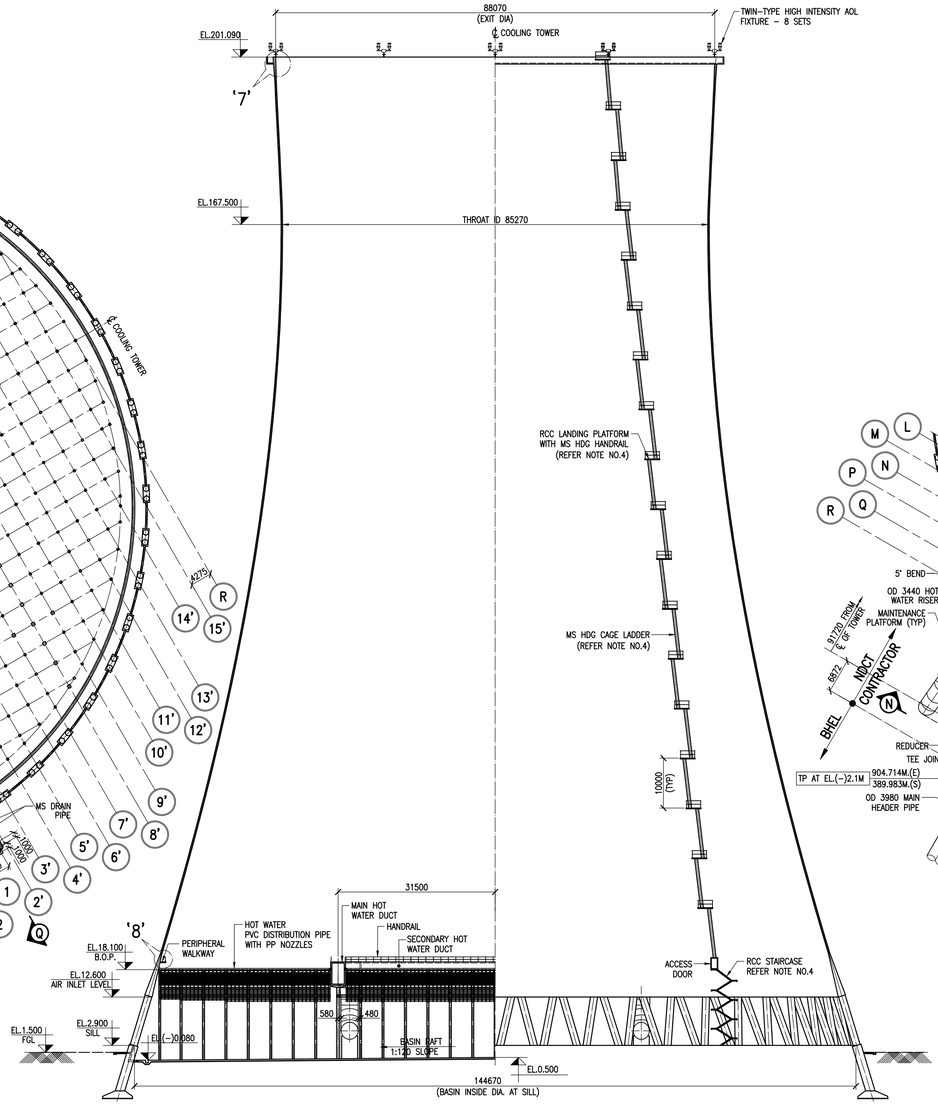
THIS DRAWING IS THE PROPERTY OF SPECTRUM Techno Consultants Pvt Ltd IT IS SUBJECT TO THEIR RECALL, AND MUST NOT BE LENT, COPIED OR REPRODUCED WITHOUT THEIR WRITTEN PERMISSION.

SHEET SIZE : A2

FILE NAME : X:\760-YADADRI NDCT\WORKING\760-E-DD-101-R2 (GAD) FOR NDCT -1 to 5).dwg

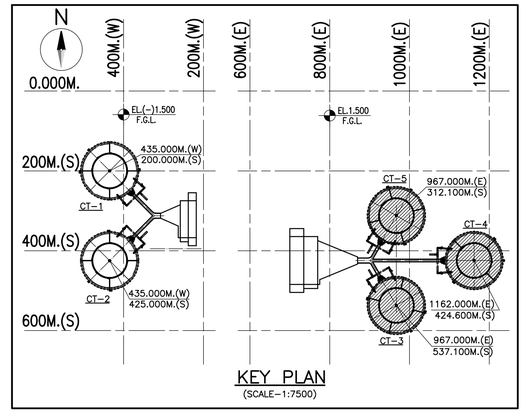


PLAN AT EL.2.900M OF CT–3
(SCALE–1:600)



HALF SECTION OF CT–3, CT–4 & CT–5
(SCALE–1:600)

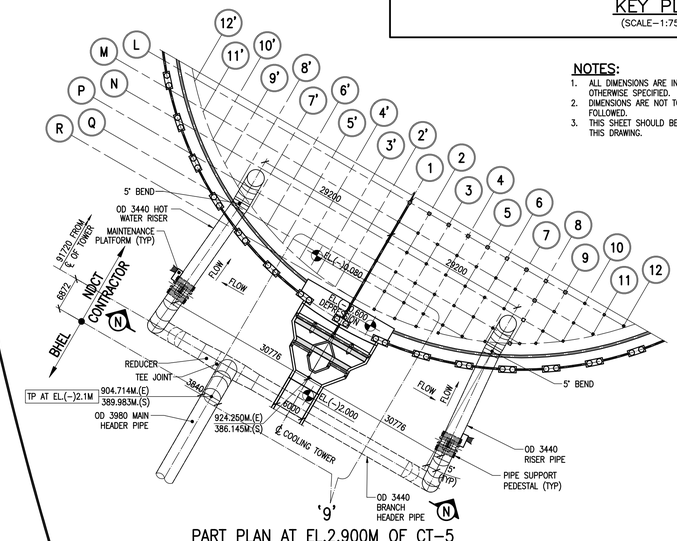
HALF ELEVATION OF CT–3, CT–4 & CT–5
(SCALE–1:600)



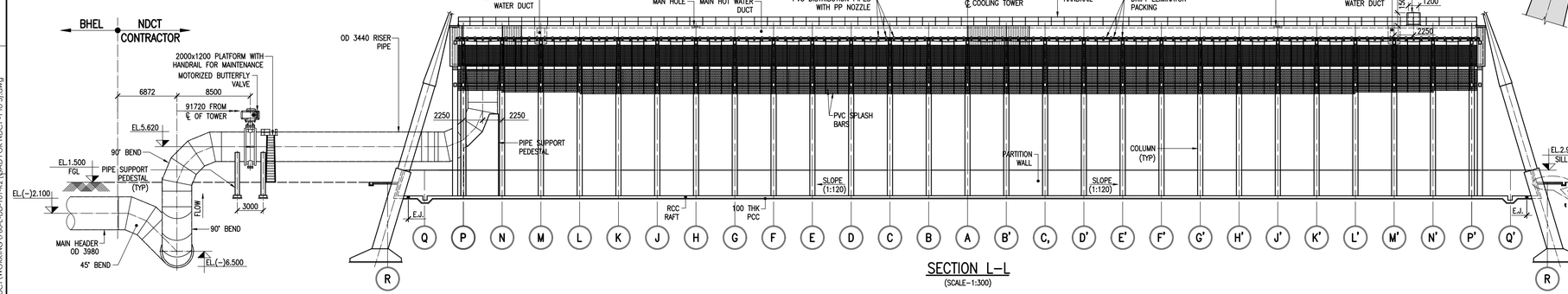
KEY PLAN
(SCALE–1:7500)

NOTES:

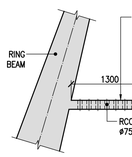
1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METER UNLESS OTHERWISE SPECIFIED.
2. DIMENSIONS ARE NOT TO BE SCALED. ONLY WRITTEN DIMENSIONS ARE TO BE FOLLOWED.
3. THIS SHEET SHOULD BE READ IN CONJUNCTION WITH SHEETS 1,2,3,5 & 6 OF THIS DRAWING.



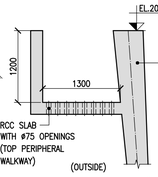
PART PLAN AT EL.2.900M OF CT–5
(SCALE–1:600)



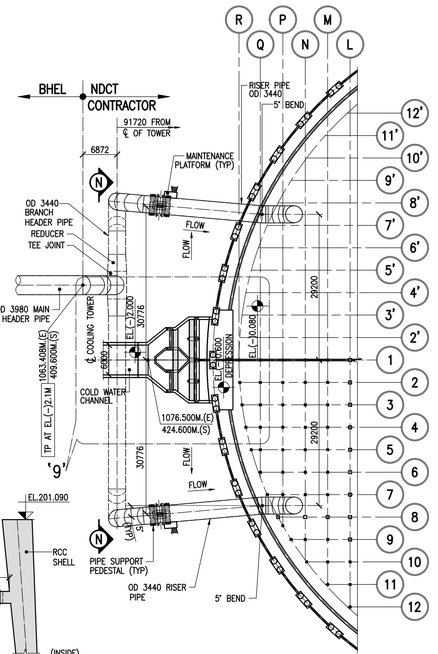
SECTION L–L
(SCALE–1:300)



DETAIL–'8'
(SCALE–1:50)



DETAIL–'7'
(SCALE–1:50)



PART PLAN AT EL.2.900M OF CT–4
(SCALE–1:600)

REV. NO.	DATE	DESCRIPTION	DRAWN
2	01/12/18	BASED ON TCE & TSGENCO COMMENTS Dt. 22/11/18	SCJ
1	10/08/18	BASED ON TCE COMMENTS Dt. 03/08/18	CDS
0	26/06/18	FOR APPROVAL	SHM

CUSTOMER: TELANGANA STATE POWER GENERATION CORPORATION LTD, TELANGANA INDIA

CONSULTANT: TATA CONSULTING ENGINEERS LIMITED, BANGALORE INDIA

EPC CONTRACTOR: BHARAT HEAVY ELECTRICALS LIMITED

NDCT CONSULTANT: SPECTRUM Techno Consultants Pvt Ltd, 401, Raikar Bhavan, Plot No. 9, Sector-17, Vashi, Navi Mumbai 400 705 India. Email : info@spectrumworld.net

PROJECT: 5x800 MW YADADRI THERMAL POWER STATION

DRAWN BY :	SHM
CHECKED BY	UNB
APPROVED BY	UKR
DATE	10/08/2018
SCALE	AS SHOWN

TITLE: GENERAL ARRANGEMENT OF NATURAL DRAUGHT COOLING TOWER (STAGE#2)

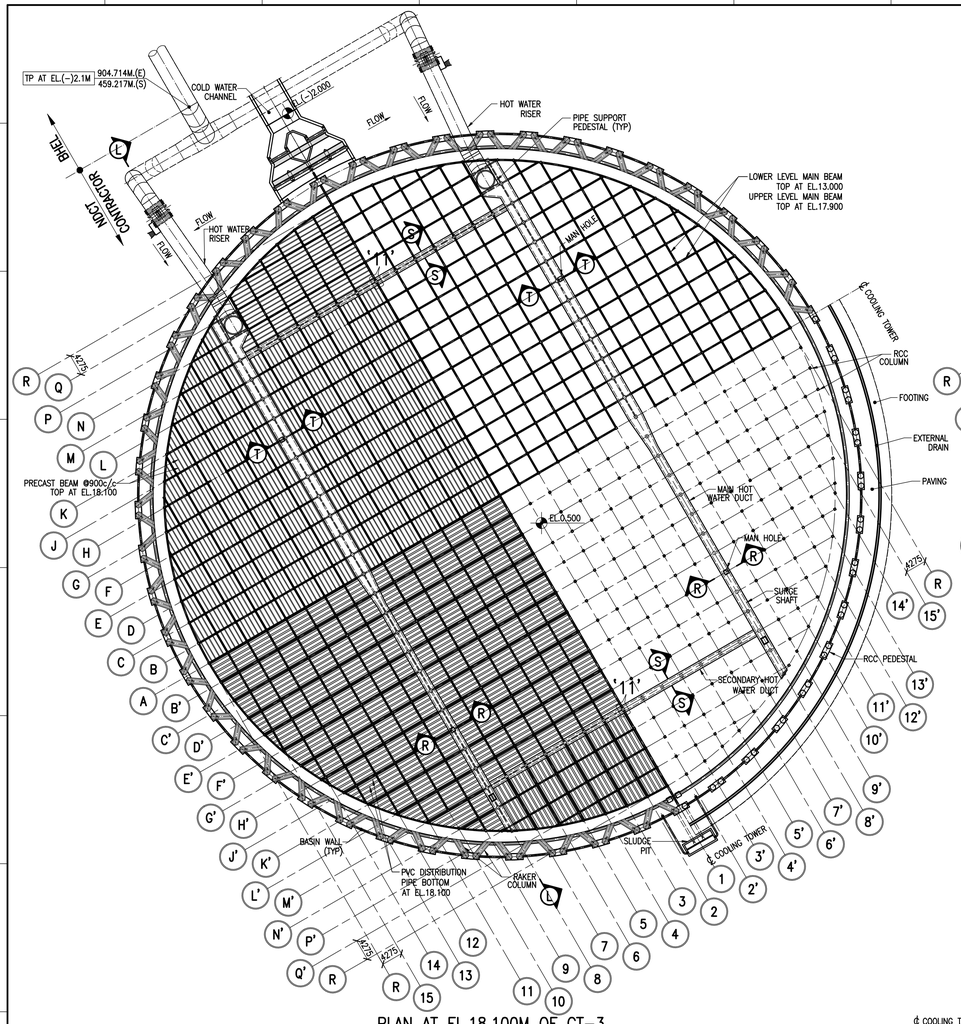
STCPL DRG.NO. 760-E-DD-101 REV.NO. 2

BHEL DRG.NO. PE-V1-417-165-N001 (SHEET 4 OF 6)

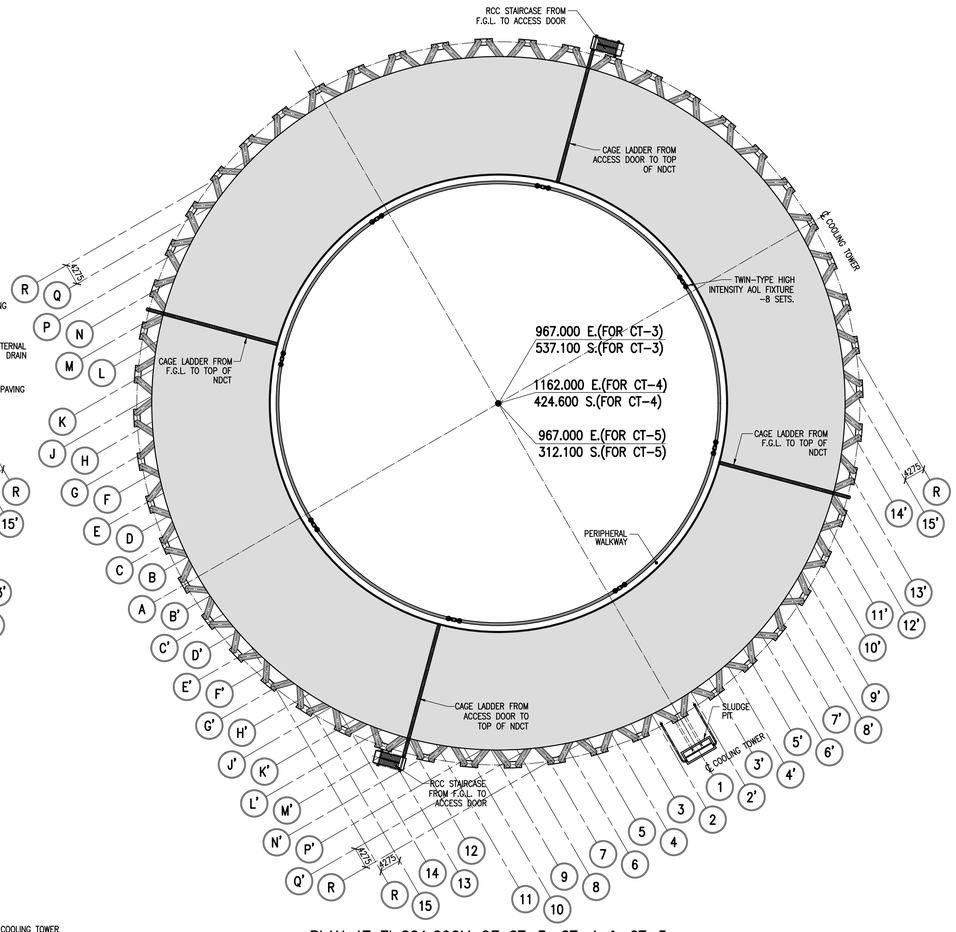
THIS DRAWING IS THE PROPERTY OF SPECTRUM Techno Consultants Pvt Ltd IT IS SUBJECT TO THEIR RECALL, AND MUST NOT BE LENT, COPIED OR REPRODUCED WITHOUT THEIR WRITTEN PERMISSION.

SHEET SIZE : A1

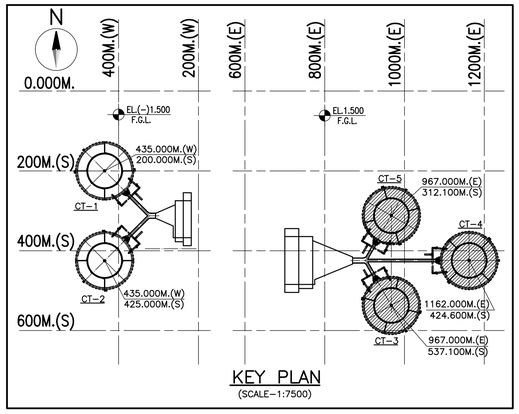
FILE NAME : X:\760-YADADRI\NDCT\WORKING\760-E-DD-101-R2 (GAD FOR NDCT -1 to 5).dwg



PLAN AT EL.18.100M OF CT–3
(SCALE–1:600)



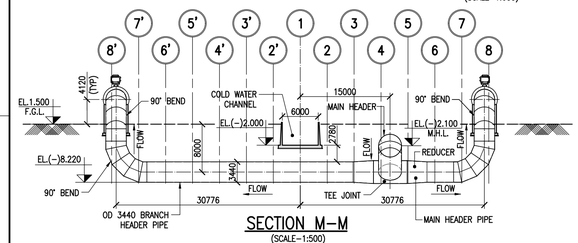
PLAN AT EL.201.090M OF CT–3, CT–4 & CT–5
(SCALE–1:600)



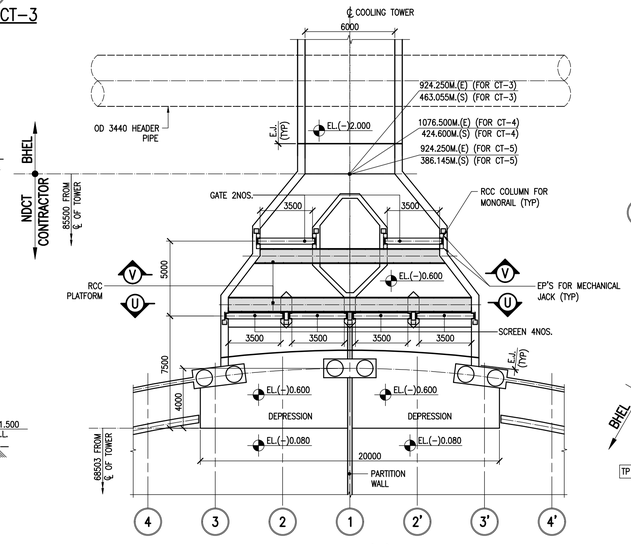
KEY PLAN
(SCALE–1:7500)

NOTES:

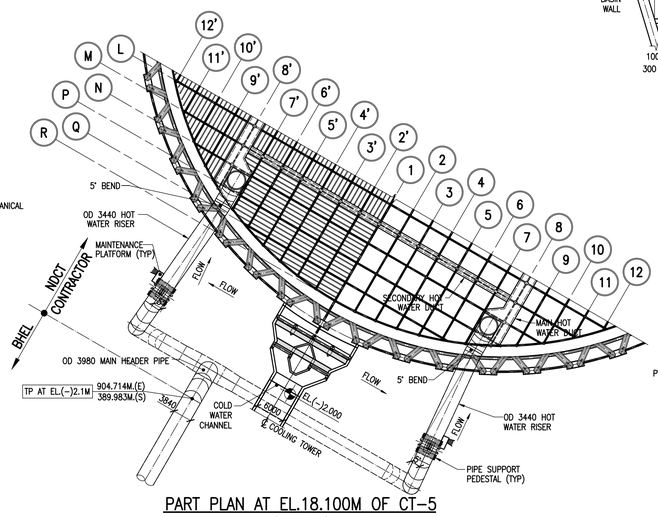
1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METER UNLESS OTHERWISE SPECIFIED.
2. DIMENSIONS ARE NOT TO BE SCALED. ONLY WRITTEN DIMENSIONS ARE TO BE FOLLOWED.
3. THIS SHEET SHOULD BE READ IN CONJUNCTION WITH SHEETS 1,2,3,4 & 6 OF THIS DRAWING.



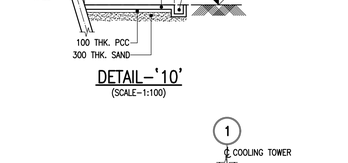
SECTION M–M
(SCALE–1:500)



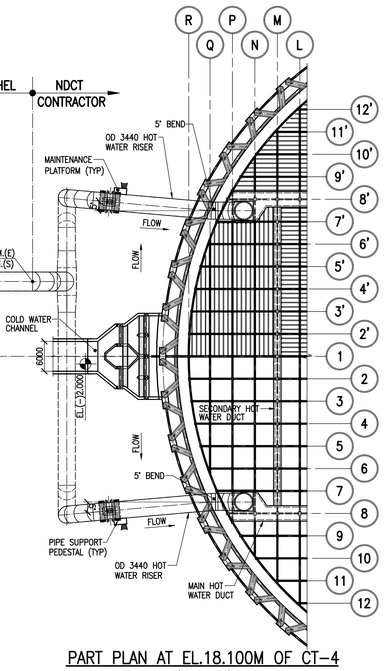
DETAIL–'9'
(SCALE–1:200)



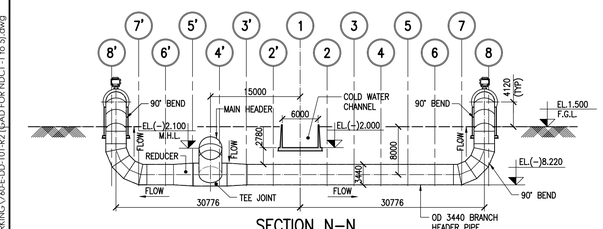
PART PLAN AT EL.18.100M OF CT–5
(SCALE–1:600)



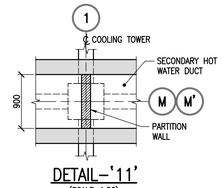
DETAIL–'10'
(SCALE–1:100)



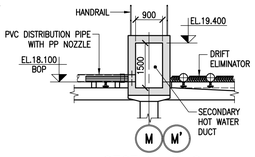
PART PLAN AT EL.18.100M OF CT–4
(SCALE–1:600)



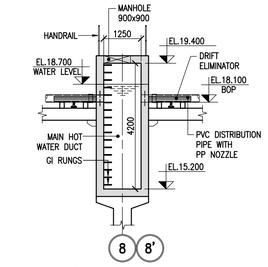
SECTION N–N
(SCALE–1:500)



DETAIL–'11'
(SCALE–1:50)



SECTION S–S
(SCALE–1:100)



SECTION R–R
(SCALE–1:100)

REV. NO.	DATE	DESCRIPTION	DRAWN
2	01/12/18	BASED ON TCE & TSGENCO COMMENTS Dt. 22/11/18	SCJ
1	10/08/18	BASED ON TCE COMMENTS Dt. 03/08/18	CDS
0	26/06/18	FOR APPROVAL	SHM

CUSTOMER: TELANGANA STATE POWER GENERATION CORPORATION LTD, TELANGANA INDIA

CONSULTANT: TATA CONSULTING ENGINEERS LIMITED, BANGALORE INDIA

EPC CONTRACTOR: BHARAT HEAVY ELECTRICALS LIMITED

NDCT CONSULTANT: SPECTRUM Techno Consultants Pvt Ltd
401, Raikar Bhavan, Plot No. 9, Sector-17, Vashi, Navi Mumbai 400 705 India. Email : info@spectrumworld.net

PROJECT: 5x800 MW YADADRI THERMAL POWER STATION

DRAWN BY :	SHM
CHECKED BY	UNB
APPROVED BY	UKR
DATE	10/08/2018
SCALE	AS SHOWN

TITLE: GENERAL ARRANGEMENT OF NATURAL DRAUGHT COOLING TOWER (STAGE#2)

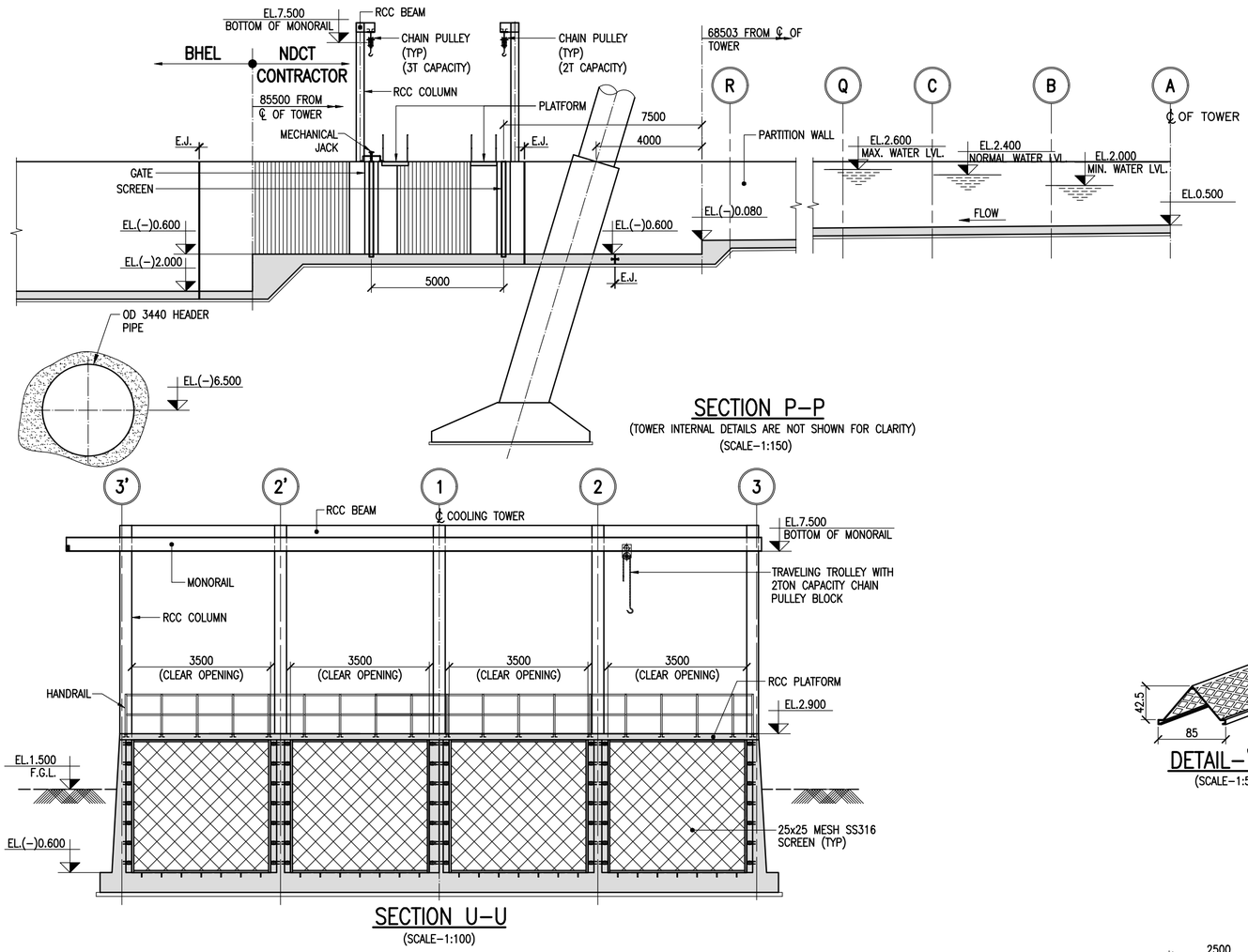
STCPL DRG.NO. 760-E-DD-101 REV.NO.

BHEL DRG.NO. PE-V1-417-165-N001 (SHEET 5 OF 6) 2

THIS DRAWING IS THE PROPERTY OF SPECTRUM Techno Consultants Pvt Ltd IT IS SUBJECT TO THEIR RECALL, AND MUST NOT BE LENT, COPIED OR REPRODUCED WITHOUT THEIR WRITTEN PERMISSION.

SHEET SIZE : A1

FILE NAME : X:\760-YADADRI\NDCT\WORKING\760-E-DD-101-R2 (CAD FOR NDCT -1 to 5).dwg

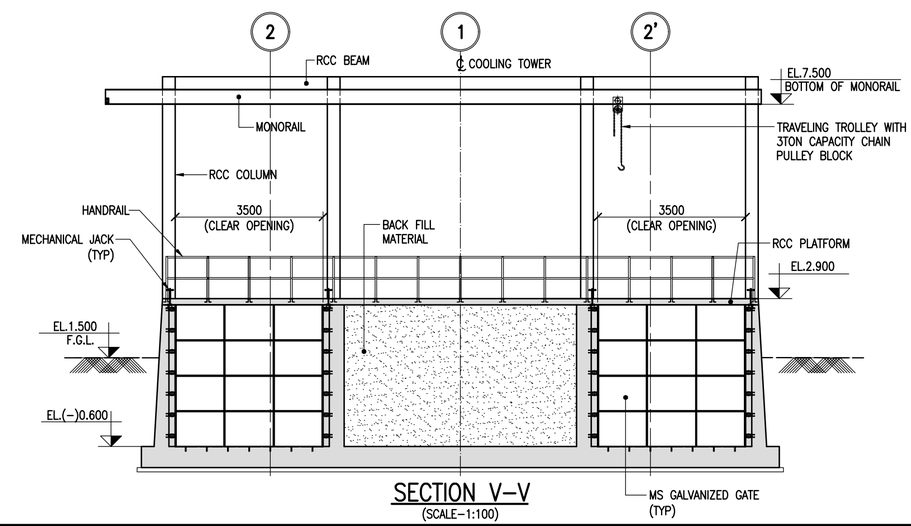


SECTION P–P

(TOWER INTERNAL DETAILS ARE NOT SHOWN FOR CLARITY)
(SCALE–1:150)

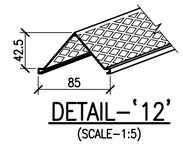
SECTION U–U

(SCALE–1:100)



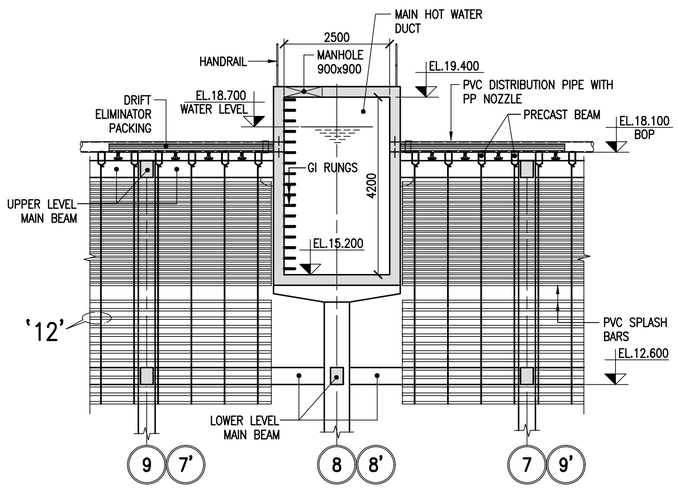
SECTION V–V

(SCALE–1:100)



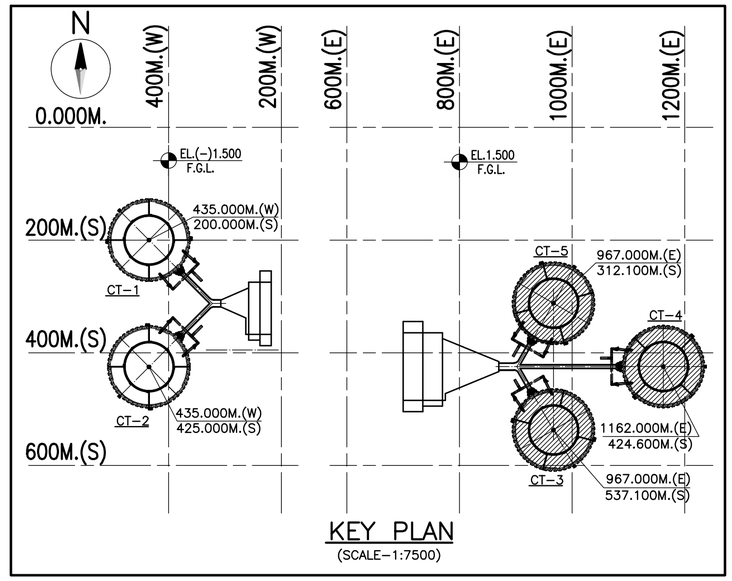
DETAIL–'12'

(SCALE–1:5)



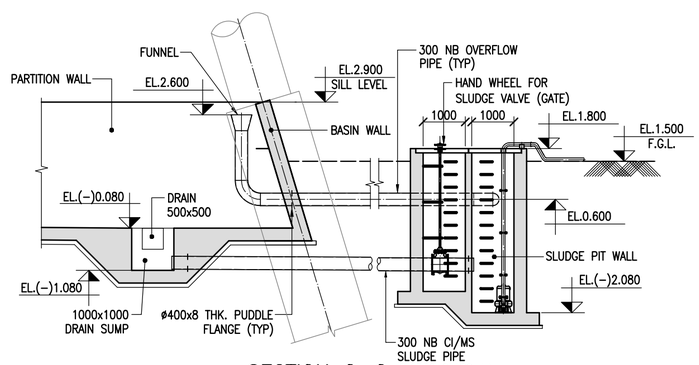
SECTION T–T

(SCALE–1:100)



KEY PLAN

(SCALE–1:7500)



SECTION Q–Q

(SCALE–1:100)

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METER UNLESS OTHERWISE SPECIFIED.
2. DIMENSIONS ARE NOT TO BE SCALED. ONLY WRITTEN DIMENSIONS ARE TO BE FOLLOWED.
3. THIS SHEET SHOULD BE READ IN CONJUNCTION WITH SHEETS 1,2,3,4 & 5 OF THIS DRAWING.

REV. NO.	DATE	DESCRIPTION	DRAWN
2	01/12/18	BASED ON TCE & TSGENCO COMMENTS Dt. 22/11/18	SCJ
1	10/08/18	BASED ON TCE COMMENTS Dt. 03/08/18	CDS
0	26/06/18	FOR APPROVAL	SHM

CUSTOMER: TELANGANA STATE POWER GENERATION CORPORATION LTD, TELANGANA INDIA

CONSULTANT: TATA CONSULTING ENGINEERS LIMITED, BANGALORE INDIA

EPC CONTRACTOR: BHARAT HEAVY ELECTRICALS LIMITED

NDCT CONSULTANT: SPECTRUM Techno Consultants Pvt Ltd
401, Raikar Bhavan, Plot No. 9, Sector-17, Vashi, Navi Mumbai 400 705
India. Email : info@spectrumworld.net

5x800 MW YADADRI THERMAL POWER STATION

DRAWN BY :	SHM
CHECKED BY	UNB
APPROVED BY	UKR
DATE	10/08/2018
SCALE	AS SHOWN

TITLE: GENERAL ARRANGEMENT OF NATURAL DRAUGHT COOLING TOWER (STAGE#2)

STCPL DRG.NO. 760-E-DD-101 REV.NO. 2

BHEL DRG.NO. PE-V1-417-165-N001 (SHEET 6 OF 6)

THIS DRAWING IS THE PROPERTY OF SPECTRUM Techno Consultants Pvt Ltd IT IS SUBJECT TO THEIR RECALL, AND MUST NOT BE LENT, COPIED OR REPRODUCED WITHOUT THEIR WRITTEN PERMISSION.

SHEET SIZE : A2

FILE NAME : X:\760-YADADRI NDCT\WORKING\760-E-DD-101-R2 (GAD) FOR NDCT - 1 to 5).dwg

	OWNER	**TELANGANA STATE GENERATION CORPN. LTD.** (TSGENCO)
	OWNER'S CONSULTANT	**TATA CONSULTING ENGINEERS LIMITED** BANGALORE, INDIA
	EPC CONTRACTOR	**BHARAT HEAVY ELECTRICALS LTD.** (BHEL)
	NDCT CONSULTANT	**SPECTRUM TECHNO-CONSULTANTS PVT. LTD.**

Doc. Prepared By		**Doc. Reviewed By**		**Doc. Approved By**	
JHB		**UNB**		**UKR**	

Revision History

Revision	Description	Date
0	For Approval	23.07.2018
1	Based on TCE Comments Dt. 02.08.2018	07.08.2018

Table of Contents

1. INTRODUCTION 5

2. DETAILED SCOPE OF CIVIL WORKS 5

3. DESCRIPTION OF STRUCTURE 6

4. MATERIAL 7

4.1 Concrete: 7

4.2 Steel: 7

5. LOADING 7

5.1 Dead Load 8

5.2 Imposed Loads (Including Constructional Loadings) 8

5.3 Wind Pressure 8

5.4 Earthquake Forces 10

5.5 Temperature Loads 10

6. LOAD COMBINATIONS 11

6.1 Load Combination for Stability Checks 11

6.2 Load Combination for Cooling Tower and Foundation System Design 11

6.3 Load Combination for Internal Fill Structure 12

7. PERMISSIBLE STRESSES 13

8. TOWER DESIGN CONSIDERATION 13

8.1 General 13

8.2 Buckling of Tower Shells 14

8.3 Opening in Shells 14

8.4 Minimum Thickness of Shell 14

8.5 Minimum Reinforcement in Shell Spacing and Placement 14

8.6 Raker Columns 14

8.7 **Foundations** 15

8.8 **Serviceability Design** 16

8.9 **Durability Requirements** 16

8.10 **Tolerances:** 16

9. LIQUID RETAINING STRUCTURES 16

10. WATER DISTRIBUTION SYSTEM 17

11. PLATFORMS, WALKWAYS, STAIRWAYS, STAIRCASES, INTERNAL GRILLAGE 17

11.1 **Internal Grillage** 17

11.2 **Platform** 17

11.3 **Staircase** 17

11.4 **Ladders** 18

12. STEEL STRUCTURES 18

12.1 **Stop logs** 18

12.2 **Hand Railing** 18

12.3 **Miscellaneous** 18

13. PAINTING 18

14. REFERENCE CODES 19

15. COMPLIANCE REPORT FOR TCE COMMENTS DT. 02.08.2018 20

1. Introduction

This document provides the design basis for NDCTs for 5 x 800 MW Yadadri Thermal Power Project of Telangana State Generation Corporation Ltd. (TSGENCO)

2. Detailed Scope of Civil Works

- Excavation and backfilling for columns, foundation and substructure below cold water basin level.
- RCC foundation raft & Cold water Basin, RCC Shell, and RCC support framework for fill and other thermos-hydraulic components.
- Hot water distribution duct.
- Painting of concrete surfaces with approved type of paint.
- Providing and installation of access doors in the shell of cooling tower including the necessary fitting and appliances on Tower Shell. The access doors will be of heavy duty MS doors duly painted with 3 coats of epoxy paints.
- Main access RCC staircase outside the tower up to Hot water Duct level, internal RCC walkways and platform, all with necessary galvanized MS pipe handrails.
- Cold water channel outlet up to terminal points.
- De-sludging arrangement for each compartment of cold water basin.
- Provision of permanent galvanized mild steel access ladder up to top of tower with adequate back-guards and landing platforms.
- Provision of peripheral drainage around cooling tower.
- Necessary site clearing and grading all-round the tower in accordance with specifications and drawings.
- Water fill test of cold water basin, cold water outlet channel.
- Hydro test of Hot water Duct.
- Supply and erection of all anchor bolts, nuts, fasteners, embedded parts and any other likewise material required for completion of work.

3. DESCRIPTION OF STRUCTURE

Ref: Drg. No. PE-V1-417-165-N002 (General Arrangement of Natural Draught Cooling Tower)

All elevations are with respect to EL. 0.000 of Power House Building, which corresponds to RL 81.500.

As given in the table below, elevations for CT-1 & CT-2 (together referred as Unit-1) are identical. Similarly elevations are identical for CT-3, CT-4, & CT-5 (together referred as Unit-2).

Item	CT-1 & CT-2	CT-3, CT-4, & CT-5
Tower Pedestal c/c diameter at sill level	144.670 m	144.670 m
Inside diameter at throat level	85.270 m	85.270 m
Inside diameter at top	88.070 m	88.070 m
Center diameter of pond wall at Basin Floor	146.458 m	146.458 m
Sill level elevation	EL. (-)0.100	EL. 2.900
Throat level elevation	EL. 164.500	EL. 167.500
Elevation of top level of tower	EL. 198.090	EL. 201.090
Air inlet level elevation	EL. 9.600	EL. 12.600 m
Basin Invert Level (at center)	EL. -2.500 m	EL. 0.500 m
Maximum Water Level (MWL)	EL. (-)0.400 m	EL. 2.600 m
Grade level (FGL)	EL. (-) 1.500 m	EL. 1.500 m
Type of fill	PVC V Bar	PVC V Bar
Effective Height of Fill Packing For Load Calculation	5.2m	5.2m
Distribution Pipe Size for Load Calculation	250 OD Max., PVC, Class 3	250 OD Max., PVC, Class 3
Drift Eliminators Material & Load	PVC, 11 kg/m^2 max.	PVC, 11 kg/m^2 max.

4. MATERIAL

4.1 Concrete:

Minimum Grade of concrete (f_{ck})

Tower Foundation	: M30
Pedestal	: M30
Pond wall	: M30
Raker Columns	: M30
Shell	: M30
Pond basin floor	: M30
Grillage columns, bracings & Beams	: M30
Precast beams	: M30
Hot water duct	: M30
Platforms	: M30
Cold water channel	: M30
Drainage Sump	: M30
Staircase	:M30
PCC	:M10
Density of Concrete:	25kN/m3
Elastic Modulus of Concrete:	$5000\sqrt{f_{ck}}$ MPa.
Coefficient of linear thermal expansion of concrete & Steel	11 x 10^{-6} ^{o}C

4.2 Steel:

Shell	: Corrosion Resistant Steel/HCRM, Grade Fe415 / 500 to IS: 1786
Foundation & other structures	: Corrosion Resistant Steel/HCRM, Grade Fe415 / 500 to IS: 1786

5. LOADING

The following loads will be considered for the design of cooling towers

a) Dead loads

b) Imposed loads (including construction loads)

c) Wind loads

d) Earthquake forces

e) Temperature (Including solar radiation)

Note: Since the strata below founding level is comprised of fresh rock as per summary of geotechnical investigation report, differential settlements due to symmetric loads are not expected. Hence, separate loads due to sinking of supports will not be considered in analysis.

5.1 Dead Load

For calculating the self-weight of the structure, the specific weight of the material will be taken as below. All other dead loads will be assessed in accordance with relevant codal provision. Dead load will include the self-weight of structure, weight of fill material, weight of water in hot water channel and distribution system including the self-weight of channel and distribution system, etc.

Concrete	: 25 KN/m^3
Water	: 9.81 KN/m^3
Steel	: 78.5 KN/m^3

5.2 Imposed Loads (Including Constructional Loadings)

Imposed loads on various structures shall be as follows:

I.	Basin, sump duct & underground pipe	: Besides earth pressure under dry & wet condition, an additional surcharge of 2.5 T/m^2 shall be taken
II.	Covers for HW distribution basin	: 0.5 T/m^2
III.	Walkways inside CT distribution basin	: 0.5 T/m^2
IV.	Landing platform & staircase	: 0.5 T/m^2
V.	Surcharge load	: 2.5 T/m^2

CW basin surcharge load shall be considered in addition to the other relevant codes. Construction loadings that may occur during execution of work will be considered in the design of the cooling tower structure.

5.3 Wind Pressure

The wind pressure on the towers will be assessed on theoretical basis as well as with the help of model test in a wind tunnel of turbulent boundary layer.

The complete cooling tower will be designed for all possible wind directions and on the basis of worst load conditions as obtained from theoretical methods.

Under the theoretical method, the circumferential net wind pressure distribution and wind pressure coefficient (p1) for the tower shell will be obtained from the "Criteria for structural design of Reinforced concrete Nature Draft Cooling Towers IS: 11504-1985. The Fourier series coefficients used to obtain the net pressures are as follows: (will be verified post wind tunnel test)

-0.00071; 0.24611; 0.62296; 0.48833; 0.10756; -0.09579; -0.01142; 0.04551

This design net pressure coefficient (p) includes the effect of internal suction and the distribution along the circumference of tower will be used at all heights of the tower.

In order to compute the quasi static design wind pressure at a given height along the circumference of the tower, the design pressure coefficient (p) will be multiplied by the wind pressure acting at that height [P(z)].

The wind pressure at a given height [P(z)] will be computed as per the stipulations of IS:875 (Part 3) - 2015. For computing the design wind pressure at a given height the basic wind speed (Vb) will be taken as **Vb= 44 m/sec** at 10.0 meters height above mean ground level. For computing design wind speed (Vz) at a height z, the risk co-efficient **K1=1**. For coefficient **K2, Terrain category 2 and class 'C'** as per table 2 of IS: 875 (Part-3) - 2015 will be considered. The wind direction for design purposes will be the one which induces worst load conditions. Topography coefficient **K3=1.0** for the tower under consideration. Since the project location is well over 120km away from the nearest sea coast, **the importance factor for cyclonic region, k4, will be considered as 1.00** as per cl. 6.3.4 of IS: 875 (Part 3) - 2015. The wind pressure at a given height will be computed theoretically in accordance to the IS codal provision given as under:

$Pz = 0.6\ Vz^2\ N/mm^2$; where $Vz = Vb \times K1 \times K2 \times K3 \times K4$

Computation of wind pressure (pz) along the wind direction by Gust Factor (GF) Method for estimating the wind load on the tower and other elements, will be based on IS: 875 (Part-3)-2015. While calculating the gust factor, the term 'b' will be taken as the diameter of the throat. Design of the tower will satisfy Peak Wind method & Gust Effective Factor method.

A load enhancement factor of 1.43 will be applied to the wind loading calculated, to account for:

i) Natural turbulence in the incident wind resulting from the bluff obstruction and wake

ii) Increase in wind speed as well as turbulence induced in the incident wind by adjacent cooling tower and the structures of significant dimensions.

A 10% increase over the enhancement factor will be considered for imperfection in construction as per IS: 11504-1985. The factor will be further increased by 10% for design of raker columns, pedestals and foundation in case wind tunnel report is not available at the time of design.

5.4 Earthquake Forces

The seismic analysis will be carried out in accordance with IS: 1893 – 2015 by modal analysis of the hyperbolic cooling towers. The earthquake analysis of the shell and its support columns including the foundations will be carried out by response spectrum method. Earthquake analysis for the fill supporting structures (RCC frames) will also be carried out by response spectrum method. For all analyses, acceleration will be considered in all 3 directions in 1:0.3:0.3 ratio. The modulus of elasticity for concrete will be as per IS: 456-2000 Clause 6.2.3.1 with an Age Factor of 1.0. All the analysis will be carried out as per the theory of elasticity.

The project lies in Zone-III

Seismic zone factor : 0.16

Response reduction factor : 3 (as per Table 4 of IS: 1893 Part 4 – 2015)

Damping : 5% of critical

Importance factor : 1.50 (Cat. 2 as per Table 3 of IS: 1893 Part 4 – 2015)

5.5 Temperature Loads

a) For temperature loading, the average annual ambient temperature variation will be considered from 15.9 deg. C to 44.3 deg. C. as per climatological data at Nalgonda.

b) Total temperature variation of 2/3 times the annual variation will be considered as loading.

c) Temperature effects due to solar radiation will be considered in addition to above. Shell will be designed for one sided solar radiation effect. Nevertheless an effective temperature difference of at least 25 deg. C across the shell thickness constant over the height and following a sine function along half the circumference will be considered.

d) The shell will be checked for thermal stresses arising due to partial operation of the tower in case the operation philosophy so demands. The calculation for stress analysis resulting from non-symmetric temperature loading will be based upon the operating condition.

e) For calculating effects of temperature loads, modulus of elasticity of concrete E_c will be reduced by 50% as per cl. 6.4.2.5.(vi) of IRC: 112 – 2011. Since this is equivalent to reduction of temperature loads by 50% and keeping E_c as it is, the later method will be adopted by multiplying working temperature loads by a factor of 0.5.

6. LOAD COMBINATIONS

Following minimum load combinations shall be considered for the design of cooling towers structures as per IS 875 (Part 5) – 1987 (reaffirmed - 2008).

6.1 Load Combination for Stability Checks

Case	Load Combination	Factor of Safety
Sliding	0.9DL + 1.0WL 0.9DL + 1.0EQL	1.5
Overturning	0.9DL + 1.0WL 0.9DL + 1.0EQL	1.5
Uplift	0.9DL + 1.0WL 0.9DL + 1.0EQL	1.25

6.2 Load Combination for Cooling Tower and Foundation System Design

Sr.No.	Load Combinations
Working Stress Design	
1	DL+ WL
2	DL +TL
3	DL +EQL
4	DL + WL + TL
5	DL + EQL + TL
Limit State Design	
4	0.9DL+1.5WL
5	1.5DL+1.5WL

6	0.9DL +1.5EQ
7	1.5DL+1.5EQ

- All these load combinations shall be checked for both basin full and empty conditions. Temperature loads, wind loads and earthquake loads of different types (and/or directions) shall be considered separately forming all possible combinations.

DL = Self Weight

WL = Wind Load

TL = Temperature Load

EQL = Earth quake load

6.3 Load Combination for Internal Fill Structure

Sr. No.	Load Combinations	Elements		
		Basin Slab	HW Duct	RCCC Grillage frame
Working Stress Design				
1	DL+SI + LL	√	√	
2	DL+SI + LL ±EQx	√	√	
3	DL+SI + LL ±EQy	√	√	
Limit State Design				
4	1.5DL+1.5SI + 1.5LL			√
5	1.2DL+1.2SI + 0.6LL ±1.2EQx			√
6	1.2DL+1.2SI + 0.6LL ±1.2EQy			√
7	0.9DL +0.9SI±1.5 EQx			√
8	0.9DL +0.9SI±1.5 EQu			√

DL - Self Weight

EQ - Earth quake load

SI - Superimposed dead load

7. Permissible stresses

For load combinations 1 to 5 in section 6.2, the stress in concrete and reinforcement shall be restricted as per working stress method of IS: 456. Any increase in allowable stresses in extreme load cases will not be considered. Crack width shall be limited to 0.1mm in case of cooling tower shell.

In limit state method of design, the stress in the reinforcement steel shall not exceed 87% of the specific characteristic strength of reinforcement steel and the compressive stress in the concrete shall not exceed 45% of the specified 28 days cube strength of the concrete as per IS:456.

Permissible stress for steel structures shall be as per IS: 800 – 2007 (WSD) based on working stresses.

For Pond wall, pedestal and distribution system (Hot water duct and secondary ducts) and cold water outlet, stresses in concrete (section 6.3, 1 to 3) will be limited as per Table 2 of IS-3370 Part II (2009) and stresses in reinforcement shall be limited to 130Mpa.

8. TOWER DESIGN CONSIDERATION

8.1 General

The complete cooling tower, including the shell, columns, ring beam and foundation, will be structurally analyzed using finite element (FE) modeling technique using the commercially available and widely popular German FE software SOFISTIK. Concrete may be assumed to be un-cracked, homogenous and isotropic. The design geometric profile, thickness variation and support conditions of shell will be considered in the structural analysis.

Analysis based on the recognized bending theory of the elastic shells will be adopted for the design of the tower and supporting structures. The shell analysis will include the following information at 10^{o} plan angle and not more than 0.05 of shell height:

A. Meridional and circumferential direct stress resultants and tangential shear stress resultants,

B. Meridional and circumferential bending moments, and

C. Displacement normal to shell mid surface.

A detailed dynamic analysis will be carried out for the complete tower for seismic forces by response spectrum method.

A single finite element model of cooling towers representing critical conditions shall be prepared for analysis in SOFISTIK.

8.2 Buckling of Tower Shells

a) Critical dynamic wind pressure will be calculated as per BS 4485 – Part 4: 1996.

b) Buckling of cooling tower will be checked as per Finite Element Analysis using SOFISTIK. The factor of safety for snap through buckling will be considered as 5. Alternatively, bifurcation buckling factor will be calculated using linear Eigen value analysis with modulus of elasticity E=0.8Ec, to account for cracked section, with a factor of safety of 7.

8.3 Opening in Shells

Opening through the shells will be provided for hot water pipes and access door.

Openings will be provided with additional reinforcement at each edge equal to 75% of the reinforcement intercepted by the openings in the direction parallel to the edges. In addition diagonal reinforcement will be provided at each corner as close as possible. The total cross-sectional area in cm^2 of this reinforcement will be 0.5d, at each corner where'd' is the shell thickness in cm.

No horizontal thrust due to the inlet piping shall be transmitted to the shell.

8.4 Minimum Thickness of Shell

A minimum thickness of 300mm shall be provided for the shell.

8.5 Minimum Reinforcement in Shell Spacing and Placement

The reinforcement used will be corrosion resistant/ HCRM of grade Fe 500 conforming to IS: 1786.

For top 1/3rd height of the shell, the circumferential reinforcement shall not be less than 0.4% of the concrete cross sectional area and meridional reinforcement shall not be less than 0.35% of the concrete cross sectional area.

Shell reinforcement for remaining 2/3rd portion will be 0.35% of concrete cross sectional area in both meridional & circumferential direction.

Spacing of reinforcing bars shall not exceed 200 mm in circumferential and 250 mm in meridional directions.

Minimum Bar Diameter : Circumferential : 10 mm

Meridional : 12 mm.

8.6 Raker Columns

Inclination of the circular raker columns will closely match the meridional slope at the shell so that the load transfer to foundation takes place through predominantly axial force in columns.

Raker columns will be designed for the most critical forces transferred to an individual raker column from superstructure considering various load combinations as under Clause 6 above. Design of raker columns shall be carried out in both limit state and working stress methods for worst load combinations acting on critical elements.

For calculating effective length of raker columns, columns will be considered as restrained at both the ends. The effective length will be taken as 0.8 and 0.6 times the length of column radially and tangentially respectively.

Minimum size of 1.2m is considered for raker column.

8.7 Foundations

The foundation shall be continuous annular raft type.

Founding level of the towers is considered to be minimum 4m below existing ground level (EGL). Net Safe Bearing Capacity (SBC) for foundation design will be considered as per recommendations provided in the approved soil investigation report (PE-DC-417-602-C001).

Modulus of subgrade reaction will be applied as springs below the raft with spring constant calculated as follows:

$K_s = \frac{SBC\ below\ 6m\ depth}{s}$, s = settlement of12mm for all towers.

Founding level for raft will be at least 1m below EGL. SBC at basin raft founding level will be considered as per recommendations of the approved soil investigation report.

The design of the cooling tower foundation structures will follow working stress method for worst load combination as per IS: 456 – 2000. Limit state method shall also be adopted for design in cases involving wind loads (DL + 1.5 WL).

The foundation of the tower shall be of minimum M-30 grade concrete resting on 100mm thick PCC of grade M10. Clear cover shall not be less than 50mm.

Foundation will be checked for safety against stability and uplift. For calculating downward load due to overburden, weight of soil directly above the annular raft will only be considered.

For the uplift check following condition will be ensured.

- Basin walls are constructer up to sill level and there is no water in the basin, superstructure column not constructed.
- No pressure relief valves will be provided in the cold water basin. The water tightness of the basin will be ensured to prevent mixing of ground water with sweet water of CW system.

8.8 Serviceability Design

Serviceability design shall be in accordance with IS: 456-2000

8.9 Durability Requirements

Clear cover for reinforcement shall be 50mm for shell.

Crack width shall be limited to 0.1 mm for Shell.

8.10 Tolerances:

The construction will be carried out with in the tolerances stipulated below as per cl. 7.3 of IS 11504

a) Shell wall center line in horizontal plane measured radially at midpoint on a 3.0m wide chord : $\pm$15mm
b) Shell wall center line in meridional plane over a height of 1.0m. : $\pm$ 10mm
c) Thickness of shell. : + 10mm or -5 mm
d) Horizontal radius of shell at any section other than shell base : $\pm$ 50 mm
e) Horizontal radius at shell base : $\pm$ 40mm

9. LIQUID RETAINING STRUCTURES

a) The cold water basin, sludge pit, cold water outlet will be designed as per IS 3370 (Part 2) - 2009. Water/soil facing parts will be designed by limiting stresses in reinforcing steel to 130 MPa as per cl. 4.4.3.1 of IS 3370 (Part 2) - 2009.

b) The structures will be designed for the following conditions:

   I. Water filled inside up to full height and no earth outside.

   II. Earth pressure at top surface level with surcharge load of 2.5t/m^2 and with ground water table outside and no water inside.

   III. The effect of provision of flap valves/ pressure release valves shall not be considered in the design of cold water basin.

c) The basin and associated structures will be checked against uplift for basin empty condition. Stability will be checked during construction stage as well.

d) Loads during construction, erection and maintenance stage will also be considered.

e) Basin floor slab will be designed to rest on raft/mat foundation including fill-pack support structures. In the space underneath the basin floor slab a layer of 100 mm thick PCC of M15 grade will be provided.

f) Minimum thickness of the basin slab shall be 300mm.

10. WATER DISTRIBUTION SYSTEM

The structural design of the water distribution system will consider the worst combination of the following loads.

I. Self-weight, other imposed loads and live load.

II. Hydraulic pressures during normal operations including pressure surges.

III. Hydraulic pressures due to mal-operation of tower or supply pumps.

The water distribution system will be provided with adequate pressure surge relief facilities to prevent pressure loading in excess of values used in the design.

11. PLATFORMS, WALKWAYS, STAIRWAYS, STAIRCASES, INTERNAL GRILLAGE

11.1 Internal Grillage

Internal grillage system comprises of cast-in-situ RCC beams and columns. Grillage system will be modeled and analyzed as moment resisting frame in STAAD Pro. The elements will be designed for self-weight and imposed loads by limit state method as per IS: 456-2000.

Minimum weight of fill will be considered as 100 kg/m^2. The structure shall be designed for a temporary point load of 1.5 kN at any point.

11.2 Platform

Peripheral platform of 1.2m clear width will be provided all around the tower circumference at top of the tower

A platform of width 1.5m shall be provided inside the tower at distribution pipe level

A minimum live load of 5.0kN/m^2 will be considered for the design of all platforms, walkways and staircases, in addition to their own weight.

11.3 Staircase

Two external dog-legged staircases shall be provided from the ground level to the water distribution level. The staircase shall have a minimum width of 1000mm and a landing width of 1000mm, with the landings not exceeding 2.5m in height. The stair riser shall not exceed 167mm and the treads shall be a minimum of 250mm.

11.4 Ladders

The tower shall be provided with 4 nos. safety ladders out of which 2 nos. will be laid from top landing of staircases up to top of NDCT and the balance 2 nos. will be laid from FGL up to top of NDCT.

MS hot dip galvanized rung ladders will be 600 mm wide, fabricated out of 60 mm x 10 mm flats with 20 mm dia. Rungs at 300 mm c/c. Stays will be provided at every 2.25 m intervals connecting the ladder with the concrete shell.

Safe cage will be provided for all ladders and will be fabricated out of 5nos. verticals of 50mm x 6mm flats with 50 mm x 6mm flats straps at 800 mm c/c.

Reinforced concrete landing platforms of size not less than 750mm x 1500mm shall be provided at every 8 to 10m height of the ladder.

12. STEEL STRUCTURES

These structures will be designed, fabricated and erected as per IS 800:2007 (WSD) and other relevant Indian Standard codes for structural steel work. All exposed steel work will be protected by hot dip galvanizing. The minimum coating will be 610gm/sq.m. and comply with IS 2629:1985, IS: 2633:1986 and IS 4759:1996.

12.1 Stop logs

Stop log gates and screen shall be designed for the worst combination of operating and maintenance conditions as per IS 800:2007.

12.2 Hand Railing

The MS pipe hand rails will be minimum 1.0m high with an intermediate member at 550mm height. The posts will be at 1200 mm spacing. The posts and runners will be minimum 40 nominal dia. And all welded construction with round corners. The tube will be as per IS 1161:1998 (for structural purpose) or equivalent. Handrails will be hot dipped galvanized after fabrication.

12.3 Miscellaneous

All access doors shall be of size 1200mm wide and 2100mm height (clear). Access door shall be of heavy duty MS doors duly painted with 3 coats of epoxy paints.

13. PAINTING

One Coat of Primer and Two Coats of Bituminous Paint conforming to IS 3384:1986 & IS 9862: 1981 will be provided to the following.

a) Basin floor internal face.

b) Internal surfaces of basin wall & basin partition wall

c) Cold water channel up to TP

d) Internal surfaces of drain chambers

e) Complete internal surface of Shell

Two coats of water proof cement paint for external surface of cooling tower shell.

Anti-corrosion treatment of RCC structures in contact with soil/earth.

14. REFERENCE CODES

1) IS: 456 – 2000Code of Practice for plain and reinforced concrete.
2) IS: 3370 – 2009 Code of practice for concrete structure for storage of liquids Parts 1 to 4.
3) IS: 800 – 2007Code of practice for general construction in steel.
4) IS: 875 – 2015 Code of practice for design loads for building and structures Parts 1 to 5.
5) IS: 1893-2015 Code of practice for criteria for earthquake resistant design of structure.
6) IS: 11504-1985 Criteria for structural design of reinforced concrete natural draught cooling towers.
7) IS: 2210 – 1988 Criteria for Design of RCCC shell structure and folded plates.
8) IS: 2204 -1962 Code of practice for construction of reinforcement concrete shell roof.
9) IS: 3043 – 1987 Code of Practice for Earthing
10) IS: 2309 - 1989 Code of Practice for the Protection of Buildings and Allied Structures against Lightning
11) IS: 5620 – 1985 Recommendation for Structural Design Criteria for Low Head Slide Gates
12) IS: 2405 - 1980 Part-1 Specification for Industrial Sieves (Wire Cloth Sieves)
13) CTI Code STD-136 Thermoplastic Materials Used for Film Fill, Splash Fill, Louvers and Drift Eliminators
14) IS: 4985 – 2000 Unplasticized PVC Pipes for Potable Water Supplies
15) CTI Code ATC-105 Acceptance Test Code for Water Cooling towers

15. COMPLIANCE REPORT FOR TCE COMMENTS DT. 02.08.2018 on R0

Sl.no.	Reference Document	Page	Comment	Response/Compliance
1	PE-V1-417-165-N002 (Design Basis Report of NDCT)	4	Please indicate BHEL drawing/doc number.	BHEL number for GAD is shown in Page 6 of the revised document.
2		5	Please check basin sill levels, Unit 1 & 2 are same, Unit 3, 4& 5 are same. Level shall be may confirmed by mechanical.	Corrected. The elevations in the table and the references are now updated for clarity.
3		6, 8, 9, 10, 12, 15, 17, 18	Please indicated latest code years.	Incorporated at all locations in the revised document.
4		7, 8	BHEL to redesign cooling tower based on wind tunnel test if any design modification has to be done based on test results same needs to consider by BHEL without extra cost & schedule Impact to TSGENCO.	Accepted.
5		9	Please update temperature load as per specification.	The temperature values are taken from climatological data of Yadadri project. The specification *PCA.CD-005.e-PCT-TS-K-02-2014-15-VII-D* mentioned in the comment doesn't appear to be in relation with this project. Kindly check and confirm.
6		13	Please confirm minimum reinforcement criteria as per specification.	The provided value, 0.35% of cross-sectional area, is taken from the specification.
7		14	Please check Unit 1 & 2 SBC will be different from SBC for Unit 3, 4&5. Please check & update as per approved soil report.	Agreed, the section in DBR is modified referring to the approved soil investigation report.
8		17	Painting shall be as per TSGENCO/TCE Approved painting specification.	Agreed. The painting details mentioned in DBR are taken from the specifications.

ANNEXURE-4

N. Raveendhar,
Chief Environmental Scientist-
Laboratory

EPTRI
ENVIRONMENT PROTECTION TRAINING & RESEARCH INSTITUTE

Lr. No: EPTRI/A. Lab/Analysis/18/DWC-25/2018-19 530 / date:12.07.2018

To

Sri Ramakrishna Keesara,
Superintending Engineer-Civil,
Construction (5x800 MW)
Yadadri Thermal Power Station,
Veerlapalem (V).
Dameracherla (M),
Nalgonda dist.

Cell - 9493120032

Sir,

Sub: EPTRI- Partial Analysis report for the surface water samples submitted – reg.
Ref: Your Letter No.SE/C/YTPS/Constn/F.Water Supply/D.No. 88/2018, dt. 15.06.2018

***

With reference to the above, please find enclosed the analysis report for the Surface Water samples submitted by your office on 18.06.2018. It may be observed that the parameters which are in the scope of NABL Accreditation are given with NABL symbol whereas for other parameters without NABL symbol. We will submit the final report at the earliest possible.

Yours faithfully,

Chief Environmental Scientist

Encl: a/a

EPTRI
CPCB & DSIR
ecognized Laboratory

ENVIRONMENT PROTECTION TRAINING AND RESEARCH INSTITUTE (EPTRI)
91/4, Gachibowli, Hyderabad -500 032, Telangana, INDIA.
Ph: +91-40-23180116, 23180119 Fax:+91-40-23180135
Email: eptri.lab@gmail.com; enquiry@eptri.com

NABL ACCREDITED
NABL T-0612, T-1451
As per ISO/IEC 17025:2005

ANALYSIS REPORT

Registration Number	: 18/DWC-25	Issue date	:	12.07.2018
Sample received	: 18.06.2018	Customer ref	:	SE/C/YTPS/Constn/F Water Supply/D No. 88/2018,
Date of Commencement	: 18.06.2018			
Date of Completion	: 11.07.2018	and date	:	15.06.2018

Name & Address of the customer : Sri Ramakrishna Keesara,
Superintending Engineer-Civil,
Construction (5x800 MW)
Yadadri Thermal Power Station,
Veerlapalem (V),
Dameracherla (M),
Nalgonda dist.

Sample Particulars	: Surface water samples
Qty-received	: ~ 5 Ltrs each – in plastic containers
Type of Sampling	: Not mentioned
Sample condition	: Suitable for analysis.
Sampling Procedure	: Samples collected and submitted by the customer
Sample Code	: **Sample Location**
SW-1	: Water sample collected from Krishna River at proposed intake point near Madachelu
SW-2	: Water Sample collected from Krishna river at upstream of proposed intake point near Madachlu
Date of Sampling	: 15.06.2018
Sampled by	: Customer
Industry representative	: Sri Ramakrishna Keesara, S.E-Civil
Sub-Contracting	: Sub-contracting was not awarded
Deviation from Standard methods	: No deviation in the test method
Sample Tested	: As per the Standard Methods for the Examination of water & wastewater by APHA, WEF, & AWWA, 23rd Edition
Remarks	: Nil

Chief Environmental Scientist

EPTRI
CPCB & DSIR
gnized Laboratory

91/4, Gachibowli, Hyderabad -500 032, Telangana, INDIA.
Ph: +91-40-23180116, 23180119 Fax:+91-40-23180135
Email: eptri.lab@gmail.com; enquiry@eptri.com

NABL ACCREDITED
NABL T-0612 T-1451
As per ISO/IEC 17025:2005

ANALYSIS REPORT

Encls: 18/DWC-25

Test Results

S.No	Test Parameter(s)	Unit	Test Method	Requirement acceptable Limit as per IS:10500: 2012	Permissible Limit in the absence of Alternative source as per IS 10500:2012	Results	
						SW-1	SW-2
1	pH	--	4500. H+B	6.5 to 8.5	No relaxation	8.0	7.9
2	Temperature	°C	2550. B	-	-	25.0	25.3
3	Electrical Conductivity	µmhos/cm	2510. B	-	-	790	765
4	Total Dissolved Solids at 180°C	mg/L	2540. C	500	2000	460	445
5	Turbidity	NTU	2130. B	1	5	0.9	0.85
6	Total Hardness as $CaCO_3$	mg/L	2340. C	200	600	170	155
7	Ca Hardness	mg/L	2340. C	200	600	95	85
8	Methyl Orange Alkalinity as $CaCO_3$	mg/L	2320. B	200	600	184	168
9	Alkalinity - Phenolphthalein	mg/L	2320. B	200	600	NIL	NIL
10	Chlorides as Cl^-	mg/L	4500. Cl^-.B	250	1000	97	95
11	Calcium as Ca	mg/L	3500. Ca.B	75	200	38	34
12	Magnesium as Mg	mg/L	3500. Mg.B	30	100	18	17
13	Fluoride as F^-	mg/L	4500. F^-.C	1.0	1.5	0.485	0.515
14	Sulphates as SO_4	mg/L	4500. SO_4^{2-}.E	200	400	56	59
15	Nitrites as NO_2	mg/L	4500. NO_2^-.B	-	-	BDL	BDL
16	Nitrates as NO_3	mg/L	4500. NO_3^-.B	45	No relaxation	4.3	4.4
17	Hexavalent Chromium as Cr^{+6}	mg/L	3500.Cr^{+6}.B	-	-	BDL	BDL
18	Biochemical Oxygen Demand (3 days at 27°C)	mg/L	IS: 3025	-	-	4	3

Opinion and Interpretation: Not Applicable.
NTU - Nephelometric Turbidity Unit
BDL: - Below Detection Limit.
Detection Limit : Hexavalent Chromium as Cr^{+6} -0.05 mg/L, Nitrites as NO_2 -0.02 mg/L
NOTE : 1.The test result relates to the items tested only

Chief Environmental Scientist

EPTRI
CPCB & DSIR
ognized Laboratory

ENVIRONMENT PROTECTION TRAINING AND RESEARCH INSTITUTE (EPTRI)
91/4, Gachibowli, Hyderabad -500 032, Telangana, INDIA.
Ph: +91-40-23180119, 23180139 Fax:+91-40-23180135
Email: eptri.lab@gmail.com; enquiry@eptri.com

ANALYSIS REPORT

Registration Number	: 18/DWC-25	**Issue date**	:	12.07.2018
Sample received	: 18.06.2018	**Customer ref**	:	SE/C/YTPS/Constn/F Water Supply/D.No. 88/2018,
Date of Commencement	: 18.06.2018			
Date of Completion	: 11.07.2018	**and date**	:	15.06.2018

Name & Address of the customer : Sri Ramakrishna Keesara,
Superintending Engineer-Civil,
Construction (5x800 MW)
Yadadri Thermal Power Station,
Veerlapalem (V),
Dameracherla (M),
Nalgonda dist

Sample Particulars	: Surface water samples
Qty-received	: ~ 5 Ltrs each – in plastic containers
Type of Sampling	: Not mentioned
Sample condition	: Suitable for analysis.
Sampling Procedure	: Samples collected and submitted by the customer
Sample Code	: **Sample Location**
SW-1	: Water sample collected from Krishna River at proposed intake point near Madacheiu
SW-2	: Water Sample collected from Krishna river at upstream of proposed intake point near Madachlu
Date of Sampling	: 15.06.2018
Sampled by	: Customer
Industry representative	: Sri Ramakrishna Keesara, S.E-Civil
Sub-Contracting	: Sub-contracting was not awarded
Deviation from Standard methods	: No deviation in the test method
Sample Tested	: As per the Standard Methods for the Examination of water & wastewater by APHA, WEF, & AWWA, 23rd Edition
Remarks	: Nil

Chief Environmental Scientist

EPTRI
CPCB & DSIR
ognized Laboratory

ENVIRONMENT PROTECTION TRAINING AND RESEARCH INSTITUTE (EPTR
91/4, Gachibowli, Hyderabad -500 032, Telangana, INDIA.
Ph: +91-40-23180119, 23180139 Fax:+91-40-23180135
Email: eptri.lab@gmail.com; enquiry@eptri.com

ANALYSIS REPORT

Encls: 18/DWC-25 **Test Results**

S.No	Test Parameter(s)	Unit	Test Method	Requirement acceptable Limit as per IS:10500: 2012	Permissible Limit in the absence of Alternative source as per IS 10500:2012	Results	
						SW-1	SW-2
19	Colour	Pt.Co	2120. B	5	15	<5	<5
20	Odour	TON	2150. B	Agreeable	Agreeable	No Odour is observed	No Odour is observed
21	Chemical Oxygen Demand	mg/L	5220. B	-	-	30	30
22	Residual free chlorine	mg/L	4500-Cl B	0.2	0.1	BDL	BDL
23	Phosphates as P	mg/L	4500 P.D	-	-	BDL	BDL
24	Total Kjeldahl Nitrogen as N	mg/L	4500. N_{org}.B	-	-	BDL	BDL
25	Total Suspended Solids at 105 °C	mg/L	2540. D	-	-	14	11
26	Ammonical Nitrogen as N	mg/L	4500. NH_3-C	-	-	BDL	BDL
27	Ammonia as N	mg/L	4500-NH_3-D	-	-	BDL	BDL
28	Anionic Detergents	mg/L	IS:13428 2005 K	0.2	1.0	<0.2	<0.2
29	Bicarbonates HCO_3	mg/L	2320.B	-	-	184	168
30	Dissolved Oxygen	mg/L	4500-O.C	-	-	5.8	6.1
31	Organic Nitrogen	mg/L	TOC Analyzer	-	-	BDL	BDL
32	Total Organic Carbon	%	Walkley and Black's (1934)	-	-	9.5	9.5
33	Silica Reactive	mg/L	4500 SiO_2 C	-	-	14.1	14.5
34	Oil & Grease	mg/L	5520. B	-	-	<1	<1
35	Sodium as Na	mg/L	3500-Na.B	-	-	82	80
36	Potassium as K	mg/L	3500-K.B	-	-	0.84	0.97

Opinion and Interpretation: Not Applicable.
TON – Threshold Odour Number
FTN – Flavour Threshold Number
BDL: - Below Detection Limit.
Detection Limit ;Residual free chlorine -1 mg/L; Phosphates as P-0.02 mg/L Total Kjeldahl Nitrogen as N – 5 mg/L; Ammonia – 0 02 mg/L Organic Nitrogen – 5 mg/L; Ammonical Nitrogen as N -5 mg/L.
NOTE :.The test result relates to the items tested only

Chief Environmental Scientist

Annexure-5

MANDATORY SPARES LIST FOR NDCT

APPLICABLE FOR UNIT- (U#1 to U# 5)

	5x800 MW YADADRI TPS - NDCT Mandatory Spares List		
Sl. No.	**Equipment/Package Name**	**Quantity**	**Remarks**
A.	**Mechanical Pakages**		
1	**Butterfly Valve**		
1.1	Complete Assembly	2 No. for Each type, Class and Size	
1.2	Electrical Actuators for the Valves as per Electrical List	Item & Quantity same as indicated in Electrical list 'B'	
2	**Chain pulley block**		
2.1	i. Load chain wheel	2 Nos.	
2.2	ii. Load chain stripping fork	10 Nos.	
2.3	iii. Hand chain wheel	4 Nos.	
2.4	iv. Ratchet pawl	2 Nos.	
2.5	v. Locking ratchet wheel	4 Nos.	
2.6	vi. Guide roller	4 Nos.	
2.7	vii. Brake disc	4 Nos.	
3	**Sump Pump**		
3.1	Complete set with Level Switch & Motor	20% of the total quantity used in the system for each type and rating or Minimum 2 Nos. whichever is higher	
3.2	Annunciation System	Item & Quantity same as indicated in C&I list 'C'	
B.	**Electrical Pakages**		
4	**415V System**		
4.1	Air Circuit Breaker		
4.1.1	Trip Coil	40 Nos	
4.1.2	Closing Coil	42 Nos	
4.1.3	Spring Charging Motor	20 Nos	
4.1.4	Spring Charging Motor with complete Mechanisim	20 Nos	
4.1.5	Spring Charged Limit Switch	20 Nos.	
4.1.6	Thermal Overload for Spring Charging Motor	10 Nos.	
4.1.7	Breaker Contact		
4.1.7.1	Main Contact (Fixed and moving) assembly	10 Sets for each type and rating	
4.1.7.2	Arcing Contact (Fixed and moving) assembly	10 Sets for each type and rating	
4.1.7.3	Breaker Jaw Contact (Bus-end & Breaker- end) assembly	10 Sets. for each type and Rating	
4.1.7.4	Sliding Contact (Fixed & Moving)	30 Sets.	
4.1.7.5	Breaker Auxiliary Contact Block	30 Nos.	

	5x800 MW YADADRI TPS - NDCT Mandatory Spares List		
Sl. No.	**Equipment/Package Name**	**Quantity**	**Remarks**
4.1.8	Arcing Chute	10 Sets for each type and rating	
4.1.9	Plug Socket with Prefab cable	10 Nos	
4.1.10	Position Limit Switch	20 Sets	
4.1.11	Indicating Lamps complete assembly		
4.1.11.1	Red	60 Nos.	
4.1.11.2	Amber	60 Nos.	
4.1.11.3	Green	60 Nos.	
4.1.11.4	White	60 Nos.	
4.1.11.5	Blue	60 Nos.	
4.1.12	CT	2 Nos. for each type and Rating	
4.1.13	Transducer	10 Nos. for each type and Rating	
4.1.14	Breaker Control Switch		
4.1.14.1	Trip / Neutral / close Switch	20 Nos. for each type and Rating	
4.1.14.2	Sw.gear / Trial / Normal Switch (Local/Remote)	20 Nos. for each type and Rating	
4.1.14.3	AC Supply On / Off Switch	20 Nos. for each type and Rating	
4.1.14.4	DC Supply On / Off Switch	20 Nos. for each type and Rating	
4.1.14.5	Motor Heater On /Off Switch	20 Nos. for each type and Rating	
4.1.14.6	DC Supply Source Selector Switch (3-position)	6 Nos. for each type and Rating	
4.1.14.7	Ammeter Selector Switch	2 Nos. for each type and Rating	
4.1.14.8	Voltmeter Selector Switch	2 Nos. for each type and Rating	
4.1.15	Voltmeter	2 Nos. for each type & Rating	
4.1.16	Ammeter	2 Nos. for each type & Rating	
4.1.17	Auxiliary Control Contactor		
4.1.17.1	Auxiliary Control Contactor DC complete	50 Nos.	
4.1.17.2	Auxiliary Control Contactor DC spare kits	50 Nos.	
4.1.17.3	Auxiliary Control Contactor DC Coils	50 Nos.	
4.2	PMCC/MCC/ACDB		
4.2.1	Contactor		
4.2.1.1	Power Contactor (AC)		
4.2.1.1.1	Power Contactor Complete Assembly	8 Nos.for each type and rating	
4.2.1.1.2	Power Contactor spare kits	20 Sets for each type and rating	
4.2.1.1.3	Power Contactor AC Coils	20 Nos. Coils for each type and rating	
4.2.1.2	Auxiliary Control Contactor (AC)		
4.2.1.2.1	Auxiliary Control Contactor Complete Assembly	60 Nos.for each type and rating	
4.2.1.2.2	Auxiliary Control Contactor spare kits	80 Sets for each type and rating	
4.2.1.2.3	Auxiliary Control Contactor AC Coils	70 Nos.for each type and rating	
4.2.2	MCCB (Power Circuit)	10 Nos. for each type and rating	
4.2.3	MCB (Control Circuit)	50 Nos.for each type and rating	
4.2.4	Switch		

	5x800 MW YADADRI TPS - NDCT Mandatory Spares List		
Sl. No.	**Equipment/Package Name**	**Quantity**	**Remarks**
4.2.4.1	Local / Remote Selector Switch	20 Nos.	
4.2.4.2	MCCB Status (On/off) Monitoring Switch/Contact	10 Nos.	
4.2.4.3	Trial / Normal /MCC Selector Switch	30 Nos.	
4.2.4.4	MCC module Service Position Limit Switch	10 Nos.	
4.2.5	Thermal Overload Relay	10 Nos. for each type and rating	
4.2.6	Sliding Contact (Fixed & Moving)	50 Sets	
4.2.7	Bus bar to MCC module Lira Contact Assembly (Bus-end & MCC Module-end)	10 Sets for each type and rating	
4.2.8	Indicating Lamps complete assembly		
4.2.8.1	Red	60 Sets	
4.2.8.2	Amber	60 Sets	
4.2.8.3	Green	60 Sets	
4.2.9	Push Button (On/Off) Complete Assembly	40 Sets	
4.2.10	CT	2 Nos.for each type and rating	
4.2.11	Ammeter	2 Nos. for each type and rating	
4.2.12	Control Transformer	2 Nos. for each type and rating	
4.2.13	Off Delay/ On Delay Timer	10 Nos.for each type and rating	
4.2.14	Switch Fuse Unit	10 Nos.for each type and rating	
4.2.15	Terminal Block		
4.2.15.1	Power Terminal Block	20% of total nos. for each type and rating used in the system orminimum two (2) no. whichever is more	
4.2.15.2	Control Terminal Block	20% of total nos. for each type and rating used in the system orminimum two (2) no. whichever is more	
4.2.15.3	End Plate for Power & Control Terminal Block	Each type 50 Nos.	
4.3	Energy Meter	2 No. For each type &rating	
5	**Control Panel/Desk Mounted Items**		
5.1	Push Button		
5.1.1	Complete assembly	10 Nos for each colour	
5.1.2	Contact Element (1NO + 1NC) Block	40 Nos.	
5.2	Selector Switch	20 Nos. for each type and rating	
5.3	Meter (Analog or Digital)		
5.3.1	Ammeter	20% for each type and range or minimum two (2) no. whichever is more	
5.3.2	Voltmeter	20% for each type and range or minimum two (2) no. whichever is more	

	5x800 MW YADADRI TPS - NDCT Mandatory Spares List		
Sl. No.	**Equipment/Package Name**	**Quantity**	**Remarks**
5.3.3	Frequency	20% for each type and range or minimum two (2) no. whichever is more	
5.3.4	MW	20% for each type and range orminimum two (2) no. whicheveris more	
5.3.5	MVAR	20% for each type and range orminimum two (2) no. whicheveris more	
5.3.6	Power Factor	20% for each type and range orminimum two (2) no. whicheveris more	
5.3.7	Synchroscope	20% for each type and range orminimum two (2) no. whicheveris more	
5.4	Indicating Lamps complete assembly	20 Nos. for each Colour and type	
5.5	Mimic Lamps	20 Nos. for each Colour and type	
5.6	MCB	4 Nos. for each type and rating	
5.7	Door Limit Switch	4Nos.	
5.8	Annunciation system		
5.8.1	Lamp Box with Facia & Lamps (LED type)	50 Nos.	
5.8.2	Hooter	2 No.	
5.8.3	Each type of PCB (for non-PLC driven system)	2(Two) no.	
6	**Actuator**		
6.1	Complete set of Actuator	2 Nos. for each type and rating	
6.2	Limit Switch	6 Nos each type and rating	
6.3	Torque Switch	6 Nos each type and rating	
6.4	Auxiliary Contact	2 nos each type and rating	
6.5	Motor	2 nos each type and rating	
6.6	Complete Seal kit	2 Set for each type and rating	
6.7	Complete O-Ring Set	2 Set	
6.8	Electronic Card	Two(2) for each type/make	
6.9	Feedback Assembly (4-20mA) for Inching type	Two(2) for each type/make	
7	**Motor**		
7.1	415 Volt Motor (above 30KW Rating upto 200KW)		
7.1.1	End Shield Cover Driving & Non-Driving End	2Set for each type and rating of Motor	
7.1.2	Driving End & Non-Driving End Bearing	2Set for each type and rating of Motor	
7.1.3	Cooling Fan	2 Nos. for each type and rating of Motor	
7.1.4	Motor Space Heater	2 Nos. for each type and rating of Motor	
7.1.5	Motor Terminal Block	2 Nos. for each type and rating of Motor	
7.1.6	Complete Set of Coupling	2 Set for each Application	
7.2	415 Volt Motor (Upto 30KW Rating)		
7.2.1	Driving End & Non-Driving End Bearing	6 Set for each type and rating of Motor	
7.2.2	Cooling Fan	4 Nos. for each type and rating of Motor	

	5x800 MW YADADRI TPS - NDCT Mandatory Spares List		
Sl. No.	**Equipment/Package Name**	**Quantity**	**Remarks**
7.2.3	Motor Terminal Block	10 Nos. for each type and rating of Motor	
7.2.4	Complete Set of Coupling	2 Set for each Application	
8	**NDCT Lighting**		
8.1	Medium intensity red flashing light	6 Nos.	
8.2	Low intensity steady red light	3 Nos.	
8.3	Control Unit for aviation warning light	4 Nos.	
8.4	Lighting transformer	2 Nos.	
8.5	M.C.C.B.	Two (2) of each type and rating	
8.6	M.C.B.	Ten (10 of each type and rating.	
8.7	Motor	Two (2) of each type and rating	
8.8	Indicating meters	Two (2) of each type and rating	
8.9	Push Button	Four (4) of each type and rating	
8.10	Contactor	Two (2) of each type and rating	
8.11	Control Transformer	Two (2) of each type and rating	
8.12	Receptacles	Two (2) of each type and rating	
C	**MANDATORY SPARE LIST (CONTROL & INSTRUMENTATION)**		
9	**Field Instruments**		
9.1	Transmitters/ Gauges/Switches etc. along with relevant accessories	20% of total or at least Four (whichever is higher) for eachtype along with accessories.	
10	**Process Connection Piping (Impulse piping/tubing, sampling piping / tubing & air supply piping as applicable)**		
10.1	Valves of all types	20% of each type, class, size & model	
10.2	Valve Manifolds (2 way/3 way/5 way)	20% of each type, class, size & model	
10.3	Fittings	20% of each type, class, size & model	
10.4	Filter Regulators	40% of each model	
11	**Control Panel/ Desk**		
11.1	Back-up panel mounted devices (Selector switches/ Push buttons/ Indicators etc.)	10% of installed capacity	
11.2	Lamps/ LEDs	200% of the total quantity	
11.3	Blank Tiles	20% of installed capacity	
11.4	MCBs	20% of each type & rating	
11.5	Fuses/ Fuse holder	200% of each type & rating	
12	**Alarm/ Annunciation system**		
12.1	Each type of module	2 nos. each	
12.2	Lamp box with Facia & Lamps (LED type)	20% of total quantity or minimum 20 nos.	
12.3	Hooter	2 nos.	
13	**Junction Box**		

	5x800 MW YADADRI TPS - NDCT Mandatory Spares List		
Sl. No.	**Equipment/Package Name**	**Quantity**	**Remarks**
13.1	Junction box	20% of total quantity for each size but minimum 4 nos.	
13.2	Terminals in Terminal blocks	20 nos. of each type	
NOTES:			
1	ANY ITEM ABOVE WHICH IS NOT REQUIRED, MAY BE INDICATED AS 'NOT APPLICABLE'. HOWEVER DURING DETAILED ENGINEERING IF THAT ITEM FOUND TO BE APPLICABLE, SAME SHALL BE SUPPLIED BY THE BIDDER WITHOUT ANY EXTRA COST TO BHEL/CUSTOMER.		
2	WHEREEVER THE QTY. IS MENTIONED IN PERCENTAGE / SETS, BIDDER TO INDICATE THE QUANTITY IN THE REMARKS COLUMN. THE QUANTITY SHALL BE VERIFIED DURING DETAILED ENGINEERING AND ANY CHANGE IN QUANTITY SHALL BE ACCOMODATED BY THE BIDDER WITHOUT ANY PRICE IMPLICATION.		
3	The Bidder shall offer mandatory spares of the same make, model and type for items which are offered in the main offer. Further, offered spare parts shall be of the same grade and shall have same performance as the instruments which they are to replace.		

Annexure-6
(Approximate quantities of Thermo-hydraullic components based on BHEL design)

			STAGE-I		STAGE-II		
SL. NO.	Description of item	Unit	Qty for NDCT#1	Qty for NDCT#2	Qty for NDCT#3	Qty for NDCT#4	Qty for NDCT#5
24	**FILLS**						
24.1	Providing & fixing UV stabilized PVC V Bars (85 mm bottom width x 42.5 mm height as shown in GA drwg) manufactured from virgin material of approved make in light greay/white/cream colour with 1.5 mm minimum uniform thickness and meeting the requirements of CTI code STD-136, including cutting, hoisiting, erection, etc. complete as per specification , data sheet and as directed by engineer	RMT	2579250	2579250	2579250	2579250	2579250
24.2	Providing & fixing SS316L Weld Mesh - (Top 2.4m 100 x 100 Mesh and Balance 2.8m with 200 x 100 Mesh) with 2.5 thk Vertical Wires x 2.5 thk Horizontal Wires, including cutting, hoisiting, erection, etc. complete as per specification , data sheet and as directed by engineer	Sq.M	98045	98045	98045	98045	98045
24.3	Providing & fixing SS 316 Sleeves with Bolts & Nuts for fastening SS weld mesh assembly to RCC beams, including hoisiting, erection, etc. complete as per specification , data sheet and as directed by engineer	Sets	86000	86000	86000	86000	86000
24.4	Providing & fixing PP Clips and SS 316 Tying Wire for fastening PVC Bars to weld mesh assembl, including hoisiting, erection, etc. complete as per specification , data sheet and as directed by engineer	Sets	2825000	2825000	2825000	2825000	2825000
24.5	Providing & fixing 14 SWG SS 316 Binding Wire for tying adjecent weld mesh assemblies and also to tying bottom of all weld meshes to RCC beams to result in a rigid assmebly, including cutting, hoisiting, erection, etc. complete as per specification , data sheet and as directed by engineer	RMT	9050	9050	9050	9050	9050
24.6	20 mm wide x 1 mm thk SS316 Straps with Clips for fixing pipes to RCC Beams	MT	3	3	3	3	3
24.7	19 mm Film Fill glued modules (ready to install) for use as "Bypass Arrestor" in the shell periphery	CuM	2000	2000	2000	2000	2000
25	**DISTRIBUTION SYSTEM**						
25.1	Providing & fixing OD 250, 225, 160 & 110 200 PVC pipes of Class 3 Grade as per IS:4985 with spigot end including drilling of holes for fixing nozzles, hoisting, grouting in RCC ducts, erecting, jointing with required accessories, testing, etc. complete as per specification and as directed for the full functionality of the system	RM	15085	15085	15085	15085	15085

Annexure-6 (Approximate quantities of Thermo-hydraullic components based on BHEL design)							
			STAGE-I		STAGE-II		
SL. NO.	Description of item	Unit	Qtyfor NDCT#1	Qtyfor NDCT#2	Qtyfor NDCT#3	Qtyfor NDCT#4	Qtyfor NDCT#5
25.2	Providing & fixing Puddle Pipes suitable for OD 250, 225, 160 & 110 pipes, in RCC Ducts. The puddle pipes shall be of same class as of the pipes. Accessories as required for jointing as per manufacturer's recommondation and as directed by engineer shall be included	Sets	686	686	686	686	686
25.3	Providing & fixing End caps with glue and additional rivets for OD 250, 225, 200, 160 & 110 PVC pipes of same class rating as of the pipes, including accessories required for jointing as per manufacturer's recommondation and as directed by engineer.	Sets	686	686	686	686	686
25.4	Providing & fixing Polypropylene Nozzles of down-spray type with solid-conical or solid-square spray pattern and of capacity and pressure head as per specifications, complete with all the necessary hardware required for fastening the nozzles to the PVC pipes including accessories, hardware, etc. as per specification & as directed. Several nozzle discharge diameters as per drawing shall be included.	Sets	16762	16762	16762	16762	16762
25.5	Providing & fixing PVC drift eliminators (wave shaped - 3 pass type (SPECTRA MODEL or equivalent with 77 mm pitch for low pressure drop) with necessary spacers, etc., to meet drift loss stipulation of 0.002% as per specification & as directed by engineer.	Sq.M	13575	13575	13575	13575	13575

SUB-SECTION – IB

SPECIFIC TECHNICAL REQUIREMENTS (ELECTRICAL)

STANDARD ELECTRICAL SCOPE BETWEEN BHEL AND VENDOR

PACKAGE: COOLING TOWER (NATURAL DRAFT)
SCOPE OF VENDOR: SUPPLY, CIVIL WORKS, ERECTION & COMMISSIONING OF VENDOR'S EQUIPMENT

PROJECT: 5 X 800 MW YADADRI TPS, NALGONDA

S.NO	DETAILS	SCOPE SUPPLY	SCOPE E&C	REMARKS
1	415V ACDB	Vendor	Vendor	415 V AC, 3 phase, 4 wire supply/ 240 V AC, 1 phase supply shall be provided by BHEL based on load data provided by vendor at contract stage for all equipment supplied by vendor. Makes shall be subject to Customer/ BHEL approval at contract stage.
2	Local starter panel/ Push Button Station (for motors)	BHEL	Vendor	Located near the motor. Makes shall be subject to Customer/ BHEL approval at contract stage.
3	Power cables, control cables and screened control cables for a) both end equipment in BHEL's scope b) both end equipment in vendor's scope c) one end equipment in vendor's scope	 BHEL BHEL BHEL	 BHEL Vendor BHEL	1. Termination at BHEL equipment terminals by BHEL. 2 Termination at Vendor equipment terminals by Vendor.
4	Junction box for control & instrumentation cable	Vendor	Vendor	
5	Any special type of cable like compensating, co-axial, prefab, MICC, fibre Optic cables etc.	Vendor	Vendor	Refer scope/ C&I portion of specification for scope of fibre Optic cables if used between PLC/ microprocessor & DCS.
6	Cabling material (Cable trays, accessories & cable tray supporting system, conduits)	Vendor	Vendor	1. Layout details between vendors supplied equipment & installation drawing by vendor. 2. BHEL will provide cable trench along with cabling material up to the terminal point approx. 10 m away from cooling tower. Further cabling (supply and E&C) shall be in vendor's scope.
7	Cable glands, lugs, and bimetallic strip for equipment supplied by Vendor	Vendor	Vendor	1. Double compression Ni-Cr plated brass cable glands 2. Solder less crimping type heavy duty tinned copper lugs for power and control cables.
8	Equipment grounding & lightning protection	Vendor	Vendor	Material and sizes shall be as per specification and subject to BHEL approval during detailed engineering stage.
9	Below grade grounding	BHEL	Vendor	MS rod material shall be provided by BHEL. All other materials/ consumables are in vendor's scope.

STANDARD ELECTRICAL SCOPE BETWEEN BHEL AND VENDOR

PACKAGE: COOLING TOWER (NATURAL DRAFT)
SCOPE OF VENDOR: SUPPLY, CIVIL WORKS, ERECTION & COMMISSIONING OF VENDOR'S EQUIPMENT

S.NO	DETAILS	SCOPE SUPPLY	SCOPE E&C	REMARKS
10	LV Motors with base plate and foundation hardware (in case applicable for NDCT)	Vendor	Vendor	Makes shall be subject to customer/ BHEL approval at contract stage.
11	Lighting System	Vendor	Vendor	In addition to other lighting system items, vendor shall consider aviation lights & their control as per statutory requirement and Lighting panels (LP) & timer control as per requirement. Further wires, any other material required for lighting system shall also be considered by vendor in their scope. BHEL will provide the power supply for LP from LDB at one location near Cooling Tower. Further distribution from LP including material is in vendor's scope.
12	Aviation Lighting	Vendor	Vendor	Make shall be subject to customer/BHEL approval at contract stage
13	Receptacles/Industrial switch-sockets	Vendor	Vendor	Make shall be subject to customer/BHEL approval at contract stage
14	Any other equipment/ material/ service required for completeness of system based on system offered by the vendor (to ensure trouble free and efficient operation of the system).	Vendor	Vendor	
15	**Engineering activities** during detailed engineering stage, including those listed below: a. Electrical load data submission in PEM format b. Electrical equipment GA drawings and layout drawings c. Cable trench/ tray layout drawings d. Control cable schedules showing routing details [including cables supplied by PEM for CT equipment]. e. Grounding and lightning protection system layouts f. Cable termination/ interconnection details (diagram)/ Cable block diagram	Vendor	--	1. Documentation shall be submitted as per project schedule for BHEL/ customer approval. 2. Vendor shall be responsible for necessary coordination with BHEL for required engineering interfacing during contract stage. 3. Any approval required from electrical inspection authority for electrical equipment shall be arranged by vendor.

NOTES:

STANDARD ELECTRICAL SCOPE BETWEEN BHEL AND VENDOR

PACKAGE: COOLING TOWER (NATURAL DRAFT)
SCOPE OF VENDOR: SUPPLY, CIVIL WORKS, ERECTION & COMMISSIONING OF VENDOR'S EQUIPMENT

1. Make of all electrical equipment/ items supplied shall be reputed make & shall be subject to approval of BHEL/Customer after award of contract without any commercial implication.

2. All QPs shall be subject to approval of BHEL/Customer after award of contract without any commercial implication.

3. In case the requirement of Junction Box arises on account of Power Cable size mismatch due to vendor's engineering at later stage, vendor shall supply the Junction Box for suitable termination.

4. Wherever BHEL is indicated above, if the scope of supply and E&C of any of the above listed items is in BHEL's Customer scope, then the respective items shall be supplied, erected and commissioned by BHEL's Customer. For such items, BHEL as indicated in SUPPLY and E&C column above shall be read as "BHEL's CUSTOMER".

TECHNICAL SPECIFICATION

FOR

NATURAL DRAFT COOLING TOWER

(ELECTRICAL PORTION)

1.0 EQUIPMENT & SERVICES TO BE PROVIDED BY BIDDER:

a) Services and equipment as per "Electrical Scope between BHEL and Vendor".

b) Any item/work either supply of equipment or erection material which have not been specifically mentioned but are necessary to complete the work for trouble free and efficient operation of the plant shall be deemed to be included within the scope of this specification. The bidder without any extra charge shall provide the same.

c) Supply of mandatory spares as specified in the specifications of mechanical equipment.

d) Erection and commissioning spares.

e) Erection & Maintenance tools & tackles.

f) Electrical load requirement for NATURAL DRAFT COOLING TOWER.

g) All equipment shall be suitable for the power supply fault levels and other climatic conditions mentioned in the enclosed project information.

h) Bidder to furnish list of makes for each equipment at contract stage, which shall be subject to customer /BHEL approval without any commercial and delivery implications to BHEL.

i) Various drawings, data sheet as per required format, quality plans, calculations, Type test & Routine test reports & certificates, operation and maintenance manuals, Complete technical literature with catalogues etc shall be furnished as specified at contract stage. All documents shall be subject to customer /BHEL approval without any commercial implications to BHEL.

j) Motor shall meet minimum requirement of motor specification.

k) LT power & control cables shall meet minimum requirement of LT power & control cables specification.

l) Cabling, earthing & lightning protection shall meet minimum requirement of cabling, earthing & lightning protection specification.

m) The sub-vendor list for various electrical items is subject to BHEL/Customer approval without any commercial implications.

2.0 EQUIPMENT & SERVICES TO BE PROVIDED BY PURCHASER FOR ELECTRICAL & TERMINAL POINTS:

Refer "Electrical Scope between BHEL and Vendor".

3.0 DOCUMENTS TO BE SUBMITTED ALONG WITH BID

3.1 Bidder shall confirm total compliance to the electrical specification without any deviation from the technical/ quality assurance requirements stipulated. In line with this, the bidder as technical offer shall furnish two signed and stamped copies of the following:

a) A copy of this sheet "Electrical Equipment Specification for NATURAL DRAFT COOLING TOWER" and sheet "Electrical Scope between BHEL and Vendor" with bidder's signature and company stamp.

b) List of Erection and Commissioning spares.

c) List of Erection & Maintenance tools & tackles.

d) Electrical load requirement.

e) If there is any conflict, customer motor specification will prevail over BHEL motor specification.

3.2 No technical submittal such as copies of data sheets, drawings, write-up, quality plans, type test certificates, technical literature, etc. is required during tender stage. Any such submission even if made, shall not be considered as part of offer.

4.0 LIST OF ENCLOSURES

4.1 Electrical scope sheet between BHEL & Vendor.
4.2 Customer Spec. for LV Motors.
4.3 General requirement of LV Motors.
4.4 Data Sheet - A for LV Motors.
4.5 Electrical Load Data Format.
4.6 Datasheet-C (to be filled by Vendor)
4.7 QP for LV motors
4.8 Customer Spec for Cooling Tower
4.9 Customer Specification for Cables
4.10 Customer Specification for Erection Cabling, Grounding And Lightning Protection
4.11 Customer Specification for Illumination
4.12 Customer Specification for LT Switchgear
4.13 QAP for Earthing and lightning protection materials
4.14 QAP for Illumination
4.15 QAP for Cable tray support-welded
4.16 QAP for Cable tray

	TITLE	SPECIFICATION NO.
	LV MOTORS	VOLUME II B
		SECTION D
	DATA SHEET-A	REV NO. 00 DATE 21.07.2017
		SHEET 1 OF 1

1.0	Design ambient temperature	:	50° C
2.0	Maximum acceptable kW rating of LV motor	:	Below 175 kW
3.0	Installation (Indoors/ Outdoors)	:	As required
4.0	Degree Of Protection (Indoor/Outdoor)	:	IP55
5.0	Type of Cooling	:	TEFC/CACA/TETV
6.0	Details of supply system		
	a) Rated voltage (with variation)	:	415V ± 10%
	b) Rated frequency (with variation)	:	50 Hz (Variation: +3% to –5%)
	c) Combined voltage & freq. variation	:	10% (absolute sum)
	d) System fault level at rated voltage	:	50 kA for 1 sec
	e) Short time rating for terminal boxes	:	50 kA for 0.25 sec
	f) LV System grounding	:	Solidly
7.0	Class of insulation	:	Class 'F' with temp rise limited to class B
8.0	Minimum voltage for starting (As percentage of rated voltage)	:	80% of rated voltage
9.0	Power cables data	:	Shall be given during Detailed engg.
10.0	Earth Conductor Size & Material	:	Shall be given during Detailed engg.
11.0	Space heater supply	:	240 V, 1Φ , 50 Hz
12.0	Rating up to which Single phase motor	:	Acceptable upto 0.20 kW
13.0	Tests	:	As per Customer motor spec.(enclosed)
14.0	Energy efficient/ Flame proof motor	:	As per Customer spec. requirement
14.0	Makes	:	As per Annexure-I

NOTE:

1. Also detail Customer spec. for Motors is to be referred as enclosed with technical spec.

VOLUME : V-B

SECTION-XV

TECHNICAL SPECIFICATION FOR NATURAL DRAFT COOLING TOWER - ELECTRICAL WORKS

CONTENTS

CLAUSE NO.	DESCRIPTION
1.00.00	SCOPE OF WORK
2.00.00	DISTRIBUTION BOARDS
3.00.00	DAY MARKING AND AVIATION WARNING LIGHTS
4.00.00	INTERIOR AND EXTERIOR LIGHTS
5.00.00	CABLES AND CONDUITS
6.00.00	GROUNDING
7.00.00	CHIMNEY LIGHTNING PROTECTION
8.00.00	COOLING TOWER LIGHTNING PROTECTION
9.00.00	TESTS
10.00.00	DRAWINGS, DATA AND MANUALS

SECTION : XV

TECHNICAL SPECIFICATION
FOR
NATURAL DRAFT COOLING TOWER
- ELECTRICAL WORKS

1.00.00 **SCOPE OF WORK**

1.01.00 The scope of supply and services shall include but not be limited to the following for Natural Draught Cooling Tower :

a) Equipment and materials as required.

b) All relevant drawings, data and instruction manuals.

c) Erection, testing and commissioning of all electrical equipment and materials supplied under this specification.

d) Obtaining statutory approvals for Aviation warning system from concerned authority.

1.02.00 Natural Draught Cooling Tower shall be provided with but not be limited to the following :

a) Normal and Emergency Power distribution and control system

b) Electrical system for chimney Elevator

c) Aviation Obstruction Lighting system

d) Normal and Emergency Lighting system

e) Cabling and conduit system

f) Earthing system

g) Lightning protection system

h) All accessories, control devices, internal wiring, fittings, supports, hangers, anchor bolts etc. which form part of the equipment or which are necessary.

1.03.00 **Power Supply**

1.03.01 The following power supply arrangement is envisaged for NDCT electricals:

~~a)~~ One (1) 415 V ± 10%, 3 phase, 4 wire, 50 Hz +3% to -5% (fault level 50 KA) supply to AC Distribution Board for Normal AC Lighting and elevator for Chimney.

b) One (1) 415 V ± 10%, 3 phase, 4 wire, 50 Hz +3% to -5% (fault level 50 KA) supply to AC Distribution Board for Normal AC Lighting for Natural Draft Cooling Tower.

~~c)~~ One (1) 415 V ± 10%, 3 phase, 4 wire, 50 Hz +3% to -5% (fault level 50 KA) supply from emergency source to Lighting board for Emergency lights and Aviation Warning Lights and elevator for Chimney.

d) One (1) 415 V ± 10%, 3 phase, 4 wire, 50 Hz +3% to -5% (fault level 50 KA) supply from emergency source to Lighting board for Emergency lights and Aviation Warning Lights for Natural Draft Cooling Tower.

Any other, supply voltage, if required for the electrical system, the same shall be arranged by the Contractor through suitable means as necessary without any price implication.

2.00.00 DISTRIBUTION BOARD

2.01.00 AC Distribution Board

AC distribution board (ACDB) shall be provided for feeding lighting distribution boards, elevator and power receptacles. This AC distribution board shall be located at EL 0.0 m of Natural Draft Cooling Tower & inside the concrete shell of the chimney. The incoming to the ACDB shall be suitable for 415V, 3 phase, 4 wire, 50 Hz supply. 10% spare feeders with minimum one (1) of each type and rating shall be provided.

2.02.00 Lighting Board

One (1) lighting board shall be provided for Normal A.C. Lighting and one (1) Lighting board shall be provided for Emergency A.C light and Aviation Warning lighting system for chimney. Similarly One (1) lighting board shall be provided for Normal A.C. Lighting and one (1) Lighting board shall be provided for Emergency A.C light and Aviation Warning lighting system for Natural Draft Cooling Tower. These lighting boards shall also be located at El. 0.0m. Each lighting distribution board shall be provided with an adequately rated dry type, delta/star, lighting transformer with Z not more than 5% and off circuit taps for variation from (-5%) to (+)5% in steps of 2.5% on the primary side. The star point of the secondary side shall be solidly grounded to get the 3 phase, 4 wire supply required for the lighting distribution board. The lighting distribution boards shall have 10% with minimum two (2) spare feeders of each type and rating.

The dry type transformer shall have the following properties :

i) Insulation class of lighting transformer shall be “F”

ii) Temperature rise shall be limited class “B”.

iii) The transformer shall be cast resin type.

2.03.00 AC Distribution Board / Lighting Board Constructional Details

2.03.01 AC Distribution Board (ACDB) and Lighting Boards shall be metal enclosed, fabricated from CRCA sheet steel minimum 2 mm thick. AC Distribution Board shall be modular construction, fixed type module, floor-mounted and free-standing type. Each module of ACDB shall be provided with hinged door. Lighting Boards shall be suitable for either wall/column mounting on brackets or floor mounting on channel sills with hinged door on the front.

2.03.02 AC Distribution Board and Lighting Boards shall be dust and vermin-proof, IP-54 or better.

2..03.03 AC Distribution Board and Lighting Boards shall be so constructed as to permit free access to the terminal connections and easy replacement of parts. Front access doors shall have padlocking arrangements.

2.03.04 AC Distribution Board and Lighting Boards shall have provision of cable entry from bottom as required, with removable gland plates. Necessary double compression type brass cable glands, heavy duty tinned copper cable lugs (for aluminium and copper conductor) shall be furnished by the Contractor.

2.03.05 Two ground pads with M10 G.I. bolts and nuts shall be provided on AC Distribution Board and Lighting Boards for connection to 75mmx10mm G.I. flat.

2.03.06 AC Distribution Board shall be complete with designation and caution notice plates fixed at front and back side and feeder name plate fixed on the front cover. Each Lighting Board shall be complete with designation and caution notice plates fixed on front cover and a circuit directory plate fixed on inside of the front cover. Circuit directory plate shall contain details of the points to be controlled by each circuit including the location of the point controlled, rating of the protective units and loading of the circuit.

The plates shall be of anodized aluminium with inscriptions indelibly etched on it.

2.03.07 Bus bar shall be electrolytic grade hard drawn aluminium, colour coded for easy identification and designed for a maximum temperature of 85 Deg.C.

2.03.08 Incoming and outgoing circuits shall be terminated in suitable terminal blocks.

2.03.09 AC Distribution Board shall consist suitable rated MCCB for over load and short circuit protection for incomer, voltmeter with selector switch and suitable PT, C.T. operated ammeter. Outgoing feeder from the AC Distribution Board shall also have MCCB with a over load and short circuit release. It is the Contractor’s responsibility to ensure proper discrimination between outgoing MCCB of AC Distribution Board and downstream MCCB of Lighting Boards.

2.03.10 Each Lighting Board shall have an incoming triple pole MCCB with neutral link with over load and short circuit release., Lighting transformer and a number of outgoing miniature circuit breakers (MCB), 9 KA rating. The lighting transformer shall be dry type housed in the cubicle.

2.03.11 Access door of AC Distribution Board and Lighting Board shall be interlocked with incoming MCCB such that the door can be opened only when the MCCB is in OFF position. Means shall be provided to defeat this interlock.

2.03.12 MCBs (9 KA rating) in Lighting boards shall be suitable for manual closing and opening and also automatic trip on overload and short circuit.

2.03.13 AC distribution board and lighting boards, after application of primer, shall be finished with electrostatic or powder painting process (thickness not less than 50 microns). For exterior shade refer to clause no.1.16.00 of section E0, Volume V-A.

3.00.00 **AVIATION OBSTRUCTION LIGHTING FOR COOLING TOWER**

3.01.00 **DELETED**

3.01.01

3.01.02 **DELETED**

3.02.00 **Illumination system for Cooling Tower**

3.02.01 Aviation Obstruction Lighting System

Aviation obstruction lighting system conforms to the requirements of the latest Indian Standard, the International Civil Aviation Organization (ICAO), the instruction issued by the Director General of Civil Aviation – India and the Directorate of Air Routes & Aerodromes' (DARA) Circular No. 3 of 1987.

White flashing high intensity LED lights of Type 'A' of table 6.3, Annex-14 of ICAO guide lines shall be provided on top of cooling tower. Six numbers of AOLs shall be provided. All AOLs are distributed over 3 phases.

Aviation control panel is provided with photoelectric switch that de-activates and activates the circuit depending on north sky luminance.

Temporary obstruction lighting will be provided during construction. Obstruction lights will be provided at the uppermost part of the tower or the surrounding scaffolding as construction proceeds upwards. As such level specified to have permanent obstruction lights is passed, that level will be provided with temporary lighting.

The aviation obstruction lights shall meet the recommendations of ICAO and all the requirement of Director General of Civil Aviation, India. Aviation lights shall be fixed only on top of cooling tower. Type of fixtures shall be as listed below.

3.03.00 The illumination system of chimney and cooling tower is governed by DCGA guidelines. In case of any changes in the guidelines in future, the same shall be adhered to.

3.04.00 **Aviation Obstruction Light Fixtures (AOL Fixtures)**

3.04.01 Each AOL fixture shall have 100% standby light i.e. twin type. Incase of failure of one light, the standby should be activated automatically with auto changeover facility giving hooter feed back. AOL shall be L.E.D type for low and medium intensity and Xenon type for high intensity lights. The degree of protection shall conform to minimum IP 55 grade protection class. High intensity lights shall have intensity step changers.

The control panel for the AOLs shall be mounted near the main distribution board at ground level.

3.04.02 Photoelectric light detectors shall be furnished and installed for cooling tower to monitor the north sky. The detector shall cause the control unit to energize the aviation lighting system when the north sky luminance. The lighting system may be energized during short periods of decreasing illumination due to abrupt periods of shadow during daylight hours, but shall not be de-energized as the result of short periods of increasing illumination levels due to lighting flashes or stray light sources when overall illumination level is such that the system is operating.

4.00.00 **INTERIOR AND EXTERIOR LIGHTS**

4.01.00 Interior platforms and staircase shall be illuminated by PHILIPS type NDC 21 or equivalent industrial well glass luminaries with 150 W HPSV lamp and separate control gear box. The number of fixtures shall be selected based on an illumination level of 70 lux for the staircase and platform. Fixture and control gear shall conform to degree of protection IP55 (min.).

At least two (2) fixtures on each platform level shall be fed from aviation warning lighting board (emergency source). All staircase lights shall also be fed from emergency system.

4.02.00 Necessary junction boxes with MCBs shall be provided on each platform to control the platform and staircase lights.

4.03.00 One (1) 15A, 240V, single phase industrial, weatherproof type, suitable for wall/ column mounting, 3-pin receptacle with suitable interlock shall be provided on each internal and external platforms. At least two 63A, 415V, three phase industrial, weatherproof type, 5-pin receptacles shall be provided at the internal platforms.

4.04.00 **DELETED**

4.05.00 **Other Areas**

Distribution & Lighting Boards area

Industrial well glass luminaries with 150 W HPSV lamp and integral control gear shall be provided in the Distribution & Lighting boards area. The lux level shall be 150 lux.

5.00.00 **CABLES AND CONDUITS**

5.01.00 Power cables shall have stranded aluminium conductor, 1100 V grade XLPE insulated, extruded PVC inner sheath galvanized steel wire armoured, overall extruded PVC sheath.

Control cables shall have stranded annealed tinned copper conductor, 1100V grade PVC insulation, extruded PVC inner sheath, galvanized steel wire armoured, overall extruded PVC sheath. Minimum size of control cable shall be 2.5 sq. mm copper. The minimum sizes of LT cable to be chosen are as below:

AL - 16 sq.mm

CU - 2.5 sq.mm

Flexible trailing cable shall have annealed tinned copper conductor, EPR insulated, reinforced with nylon cord, cores laid up, HDCSP inner sheathed, cotton taped and HDCSP overall sheathed conforming to IS:9968.

Power, control and trailing cables shall be FRLS type.

Lighting wires shall have stranded copper conductor PVC insulated, 1100 V grade, laid in galvanized GI conduits and shall be of following minimum sizes:

- From Lighting panels to junction boxes : IC, 6 SQ.mm
- From junction boxes to lighting fixtures (Number of wires per lead as required) : IC, 2.5 SQ.mm
- From Lighting panels to receptacles (15A) (A1) : IC, 6 SQ.mm

5.02.00 Required number of GI pipe conduit of size not less than 32 mm dia shall be provided. Each conduit riser shall run from the lowest embedded pull box to the highest junction box. The lowest pull box shall be located 450mm above grade in the chimney / Cooling Tower. Pull boxes shall be installed at every 10m intervals vertically. The conduit risers shall run adjacent to the stairs such that the pull boxes become easily accessible from the stairs.

5.03.00 Each conduit riser shall have one circumferential conduit at each platform level. The circumferential conduit at each level shall be provided with three (3) more junction boxes equally spaced at the locations of the aviation warning lights. Suitable conduits shall also be provided from the junction box to the respective light point. The GI pull boxes and junction boxes shall be of size atleast 150mm x 150mm x 100mm, 3mm thk, preferably embedded in the concrete shell.

5.04.00 The conduits shall be electrically connected to all circumferential reinforcing rods which are in turn connected to the down conductors.

5.05.00 Conduit joints and connections shall be made thoroughly watertight and rust proof by application of white lead for embedded portion or red lead for exposed portion.

5.06.00 Conduits shall be hot dip galvanised conforming to relevant IS.

5.07.00 Conduit system shall be electrically bonded to the grounding system.

6.00.00 **GROUNDING**

6.01.00 The Contractor shall provide a complete grounding system including underground matas needed for the RCC chimney & Cooling Tower.

6.02.00 The grounding installation work shall conform to the requirements of the Indian Electricity Rules and Code of Practice for Earthing (IS: 3043) as amended up-to-date and grounding notes & details. DWG No. 13A06- DWG-E-0600 attached with the specification. Each piece of electrical equipment/ structure shall be bonded to the grounding system at two (2) points min.

6.03.00 The main ground mat shall be of bare MS round bar of diameter identical to power house ground mat conductor, buried in earth at a min. depth of 1000 mm below finished grade level. Earth electrode of size 40 MM dia x 3 M length driven into the ground and connected to the ground grid conductor shall be provided, as required, to bring down the ground resistance.

6.04.00 Riser from the ground grid shall project 300 mm above grade / concrete floor level. All ground connections below grade shall be made by electric arc welding with low hydrogen content electrode. Above grade 75mmx10 mm galvanised mild steel (450 g/m^2 zinc coating min) flats shall be run as main ground conductors securely fixed at intervals not exceeding 1500 mm.

One end of the galvanized mild steel flat shall be connected to the MS round bar riser by electric arc welding and the other end to the equipment by welding / bolting, as necessary. All welded portion shall be painted with bituminous paints against possible corrosion.

6.05.00 The chimney / Cooling Tower ground mat shall be connected to the nearest main plant ground mat by MS round bar at least at two distinct locations.

6.06.00 Ground grid resistance of the grounding system shall not be more than 0.5 ohm.

6.07.00 The ground conductor sizes for grounding of electrical equipment, lighting fixtures, junction boxes etc. shall be as follows :

i)	Distribution Boards, Lighting Panels and motors above 90 KW	:	50 mm x 6 mm GI Flat
ii)	Motors above 30 KW upto 90 KW	:	35 mm x 6 mm GI Flat
iii)	Motors above 5 KW upto 30 KW	:	25 mm x 3 mm GI Flat
iv)	Motors upto 5 KW	:	8 SWG GI wire
v)	Lighting Fixtures, junction boxes, conduits, etc.	:	16 SWG G.I. wire

7.00.00 **DELETED**

7.01.00 **Air Termination Rod**

The vertical air terminal rods shall be installed at the top of chimney to protect from lightning strokes.

Installation of air terminal at top the chimney for lightning protection shall be 20mm dia lead coated solid copper rod. The projected length of the rod shall be as required to protect the object from lightning stroke.

All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size 75 x 10 mm galvanised steel flats.

The air terminal rod shall be properly fixed on the top of the chimney to withstand very high wind pressure.

7.02.00 **Circumferential Band**

The circumferential band shall be 75 x 10 mm galvanised steel flat fixed to the circumference of top of chimney at interval not more than 1.0 m. This shall be mounted with suitable anchors at such a height as to be accessible from the top of platform for maintenance. The anchors shall be embedded in concrete wall of the stack.

7.03.00 **Down Conductors**

Minimum four number of 75mm x 10mm GS flat down conductors shall be provided. These shall be not more than 15m apart on the periphery of the stack at the ground level. The down conductor shall be connected to circumferential band at the top portion of the stack and other end connected to the nearest mild steel rod riser from ground electrode. These conductors shall be continuous as far as practicable. Intermediate breaks shall be electrically bonded to form continuous circuit from top to bottom. Lapping of down conductor by bolting is not acceptable.

The down conductor shall be clamped along the surface at intervals of 1500mm by GS clamps. The connection between GS flat & GS clamps shall be done by arc welding.

At each chimney platform level, a circular band shall be provided which will be made of 75 x 10 mm GS flat and electrically connected to each down conductor.

7.04.00 **Testing Points**

Test joint shall be provided for each down conductor before termination on earth electrode at a height 1.5m from graded level. Test point shall be covered in 150 x 150 x 150 mm GS box. No sharp bends shall be formed in the down conductors and shall be kept as straight as possible.

7.05.00 **Clamps, Anchors Etc.**

All connections, clamps, anchors etc. of the lightning protection system shall be made of GS fittings. All joints or any other form of electrical connections, unless otherwise specified, shall be clamped or bolted by high pressure contact to form a connection of adequate current carrying capacity and mechanical strength. Soldered connections will not be permitted.

7.06.00 **Vertical and Horizontal Reinforcing Bars**

All reinforcing bars shall be properly bonded and connected to earthing system which shall be separate than lightning protection.

The testing point of the down conductors shall be convenient for testing. Testing point shall be phosphor-bronze gunmetal or copper or other suitable.

7.07.00 **Temporary Lightning Protection**

During construction of chimney, temporary lightning protection shall be maintained by connecting the reinforcement bars to two earth electrodes by means of two 75x10mm GS conductors. These temporary protections shall be provided even after the completion of the chimney till such time the permanent protections are installed.

To avoid maleffect of highly corrosive atmosphere around the chimney due to flue gas and weather, the exposed conductors, connections, clamps, base plate etc. shall be protected by hot dip galvanizing. All site-welded joints conductors shall be coated with anti corrosive paints over a coat of primer.

8.00.00 **COOLING TOWER LIGHTNING PROTECTION**

Lightning protection system shall confirm to the requirements of IS: 2309 amended up-to-date and Lightning protection notes and details. DWG. No. 13A06-DWG-E-1000 attached with the specification.

8.01.00 **Air Terminations**

The vertical air terminal rods shall be installed at the top of cooling towers to protect these objects from lightning strokes.

The vertical air terminal except for chimney shall be made of 20 mm dia galvanised steel rod. The projected length of the rod shall be as required to protect the object from lightning stroke.

The air terminal rod shall be properly fixed on the top of the structure to withstand very high wind pressure.

All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size 75 x 10 mm galvanised steel flats.

8.02.00 **Down Conductors**

The down conductors shall be 75 x 10 mm galvanised steel flats. One end of this shall be connected with air terminal rod/horizontal conductor at the top of structure and other end connected to the nearest mild steel rod riser from ground electrode.

Each down conductor shall have an independent earth termination. In no case conductors of the lightning protection system shall be connected with the conductor of grounding system above ground level.

The connection between each down conductor and rod shall be made via test link located at approximately 1500 mm above ground level.

The down conductor shall be laid straight and sharp bends shall be avoided as far as practicable. The down conductor shall be clamped along the surface at intervals of 1500mm by GS clamps.

The down conductors shall be protected at the ground level against mechanical injury by means of non-metallic pipes, viz. PVC pipes filled with bituminous compound.

8.03.00 **Testing Points**

Test joint shall be provided for each down conductor before termination on earth electrode at a height 1.5m from graded level. Test point shall be covered in 150 x 150 x 150 mm GS box. No sharp bends shall be formed in the down conductors and shall be kept as straight as possible.

8.04.00 **Clamps, Anchors Etc.**

All connections, clamps, anchors etc. of the lightning protection system shall be made of GS fittings. All joints or any other form of electrical connections, unless otherwise specified, shall be clamped or bolted by high pressure contact to form a connection of adequate current carrying capacity and mechanical strength. Soldered connections will not be permitted.

8.05.00 **Temporary Lightning Protection**

During construction of cooling tower, temporary lightning protection shall be maintained by connecting the reinforcement bars to two earth electrodes by means of two 75x10mm GS conductors. These temporary protections shall be provided even after the completion of the chimney till such time the permanent protections are installed.

9.00.00 **TESTS**

9.01.00 **Type Tests**

The type tests for fire proof / penetration seal for floor and wall opening/ fire stop system for bottom of electrical switchgear/ panel base are as under:

i) Fire rating test.

ii) Hose Stream test

iii) Accelerated aging test.

iv) Fire rating test on the penetration seal system built out of accelerated aged components followed by hose stream test.

v) Temp. rise test for cable in the fire stop.

vi) Water absorption test followed by fire rating test.

vii) Flame Resistance test for fire retardant coating material.

viii) Anti-rodent test.

Illumination in different areas are as per designed lux level should be established.

9.02.00 **Test Certificates**

Certified copies of all tests carried out at works and at site shall be furnished in requisite number of copies.

Test reports shall be complete with all details and shall also contain limit valves specified in the relevant standards, wherever applicable, to facilitate review of Test Report/ Certificates.

The fire proof sealing system shall be installed only after receipt of approval of the test reports.

10.00.00 **DRAWINGS, DATA AND MANUALS**

10.01.00 **To be submitted with the Bid**

10.01.01 Typical general arrangement drawing of Chimney / Cooling Tower showing location of lighting fixtures, lightning protection system, grounding system etc.

10.01.02 Typical general arrangement drawing of A.C. distribution board, lightning board.

10.01.03 Catalogue cuts of various types of lightning fixtures, major components, cables, conduits etc

10.01.04 Type Test Certificate of various equipment

10.02.00 **To be submitted for Approval (A) / Reference (R) and subsequent Distribution**

10.02.01 Dimensional general arrangement drawing of chimney / Cooling Tower showing disposition of aviation warning lights, interior lights on platforms and stairs, receptacles, A.C. distribution boards, lighting boards including their fixing arrangements (A).

10.02.02 Arrangement drawings for lightning protection and grounding system (A)

10.02.03 Single line drawing of A.C. distribution boards and lighting boards (A)

10.02.04 Cable and Conduit layout (A)

10.02.05 Technical data sheet of all equipment / components (A).

10.02.06 Instruction Manuals and Catalogue cuts of all equipment (R)

The manuals shall clearly indicate the method of installation, check-up and tests to be carried out before commissioning of the equipment.

10.02.07 Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.

10.03.00 The Contractor may note that the drawings, data and manuals listed are minimum requirement only. The Contractor shall ensure that all other necessary information required to fully describe the equipment / system offered are submitted with his Bid.

SUB-SECTION – IC

SPECIFIC TECHNICAL REQUIREMENTS (C &I)

TELANGANA STATE POWER GENERATION CORPORATION LTD

5X800 MW YADADRI, NALGONDA

C&I TECHNICAL SPECIFICATION
FOR
NATURAL DRAFT COOLING TOWER

SPECIFICATION No: PE-TS-417-145-IXXX

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT DIVISION
NOIDA, INDIA

BHEL	**5x800 MW TSGENCO YADADRI TPS** **CONTROL & INSTRUMENTATION** Technical specification for **NATURAL DRAFT COOLING TOWER**	SPEC NO.: **PE-TS-417-145-IXXX** VOLUME SECTION 'D' REV. NO. 00 | DATE : 20.07.2017 SHEET OF

INDEX

BHEL	**5x800 MW TSGENCO YADADRI TPS** **CONTROL & INSTRUMENTATION** Technical specification for **NATURAL DRAFT COOLING TOWER**	SPEC NO.: **PE-TS-417-145-IXXX** VOLUME SECTION 'D' REV. NO. 00 | DATE : 20.07.2017 SHEET OF

INDEX:

1. INDEX
2. SPECIFIC TECHNICAL REQUIREMENT
3. FIELD SENSORS & INSTRUMENTS
4. INSTRUMENTS QUALITY PLAN
5. ACTUATOR SPECIFICATION & DATA SHEET
6. SPECIFICTION AND DATA SHEET FOR LOCAL CONTROL PANEL
7. QAP FOR LOCAL CONTROL PANEL
8. MANDATORY SPARES
9. KKS PHILOSOPHY

BHEL	**5x800 MW TSGENCO YADADRI TPS** **CONTROL & INSTRUMENTATION** Technical specification for **NATURAL DRAFT COOLING TOWER**	SPEC NO.: **PE-TS-417-145-IXXX** VOLUME SECTION REV. NO. 00 | DATE : 20.07.2017 SHEET OF

SPECIFIC TECHNICAL REQUIREMENTS

SPECIFIC TECHNICAL REQUIREMENTS (C&I):

1.0 Operation & Control of **NATURAL DRAFT COOLING TOWER** system shall be from plant DCS (BHEL Scope).

2.0 Bidder to include all the instruments (for the measurement of pressure, temperature, level, flow vibration etc.) required for the package along with necessary fittings, accessories and valve manifold etc. All field instruments shall be weatherproof, drip tight, dust tight and splash proof suitable for use under outdoor ambient conditions prevalent in the subject plant. All field-mounted instruments shall be mounted in suitable locations where maximum accessibility for maintenance is achieved. Anticorrosive paint shall be applied to the field mounted enclosures / instruments. All the field instruments shall also be provided with SS tag nameplate and double compression type Nickel-plated brass cable gland. Gaskets, Fasteners, Counter and mating flange shall also be included wherever required with the field instruments.

3.0 All local gauges as well as transmitters, sensors and switches for parameters like pressure, temperature, level, flow, vibration etc. as required for the safe and efficient operation and maintenance under the scope of specification shall be provided. The necessary root valves, impulse piping, drain cock, gauge-zeroing cocks, valve manifolds and all other accessories required for mounting / erection of these local instruments shall be furnished even if not specifically asked for. The proposal shall include the necessary cables, flexible conduits, junction boxes and accessories for the above purpose. Double root valves shall be provided for all pressure tapping where the pressure exceeds 40 Kg / Cm2.

4.0 The solenoid operated valves/ damper/gates shall have limit switches for open/ close feedback. Solenoid valve shall be rated for 24 V DC only.

5.0 The junction boxes/LIEs for termination of instruments /solenoid valve limit switches etc are in bidder's scope.

6.0 Removable type Pitot Tube at each hot water inlet pipe header to measure the flow (during Performance Guarantee Test only). The Pitot tube shall be left with customer after the completion of the test.

7.0 Pressure and Temperature measuring Instruments at hot & cold water duct/piping at terminal points shall be provided. Further, instrument tapings

provision on hot duct/piping and cold water duct/piping for carrying out flow and temperature measurement during Performance Guarantee test.

8.0 Anemometer (for measuring of wind velocity) and Psychrometer shall be supplied.

9.0 All testing and calibrating instruments required for site performance tests shall be arranged by the supplier without any extra cost and time implication.

10.0 The make/model of various instruments/items/systems shall be subject to approval of owner/purchaser during detailed engineering stage. No commercial implication in this regard shall be acceptable. In case of any conflict or repetition of clauses in the specification, the more stringent requirements among them are to be complied with.

11.0 Vendor representative shall be available for 3-4 days at BHEL Electronic Division (EDN) Bangalore during testing of DCS.

12.0 Vendor representative shall be available for 6-7 days during commissioning time at site.

13.0 The design, manufacture, inspection, testing, site calibration and installation of all C&I equipment and systems covered under this specification shall conform to the latest editions of applicable codes and standards eg. ANSI, ASME, IEEE, ISO, IEC, IGCI, AWS, NFPA, AISC, IGS, SAMA, UBC, UL, NESC, NEMA, ISA, DIN, VDE, IS etc.

14.0 For instrument & control cable scope of supply refer ‘Electrical scope sheet between BHEL & vendor’.

15.0 Instrument installation drawings are to be provided by bidder. All instrument fitting and erection hardware as per instrument installation diagram shall be in bidder’s scope.

16.0 The make of all the items shall be from approved sub-vendor list.

17.0 Bidder shall provide Cable Schedule in BHEL excel format provided in Electrical portion of the specification. Also, cable interconnections details for complete system shall be in Bidders’ scope.

18.0 Editable & pdf copy of Drawings/Documents and data to be furnished after award of the contract:

- Control & operational write-up for the system
- Recommended control scheme/ logic diagram
- Process manuscript for implementation in DCS
- List of Drives (Solenoid valves etc)

- I/O list (DCS)
- GA & wiring diagram of local panel.
- Power requirement.
- Field instruments quality plan.
- Instruments data sheet.
- JB grouping document.
- Cable schedule and cable interconnection drawing.
- Instrument schedule
- Alarm Schedule
- SOE schedule
- Instrument hook-up diagram.
- Any other document decided during detailed engineering.

NOTES:

1. All equipment items shall be of latest design with proven on track record from reputed experienced manufacturers of specified type and range of equipment. The make/model of various instruments/items/systems and instrument sub-vendor shall be subject to approval of BHEL/Customer during detailed engineering stage.

2. The above given scope is indicative & minimum. Any item/ equipment not indicated above however required for the completeness of the system is to be supplied by bidder without any technical, commercial and delivery implication to BHEL.

3. Documents of C&I System shall be submitted to end user/owner for approval during detail engineering. Changes, if any, shall be accommodated by the bidder without any price/time implication.

4. Uniformity of make and type of instruments and control components shall be followed throughout for rationalization of spares' inventory, except for certain proprietary items where this requirement cannot be met.

FORM NO. PEM-6666-0

	5x800 MW TSGENCO YADADRI TPS	SPEC NO.: **PE-TS-417-145-IXXX**
	CONTROL & INSTRUMENTATION Technical specification for	VOLUME
		SECTION
	NATURAL DRAFT COOLING TOWER	REV. NO. 00 / DATE : 20.07.2017
		SHEET OF

FIELD SENSOR & INSTRUMENTS SPECIFICATIONS

approval

3.03.00 LEVEL SWITCH

3.03.01 FLOAT OPERATED

1.	Float material	:	SS-316
2.	Wetted parts	:	SS-316
3.	Float chamber	:	Stainless steel/Carbon steel, construction welded
4.	Float chamber mounting	:	Side mounted
5.	Fluid connection	:	Side – Side
6.	Fluid connection size	:	1" ANSI RF Flange (rubber line, if required)
7.	Drain	:	½ inch NPT with Plug
8.	Pressure rating of chamber	:	Minimum 1.5 times of design pressure
9.	Repeatability	:	+/- 1.5 mm or better
10.	Switch housing	:	Stainless Steel
11.	Switch housing type	:	IP- 65
12.	Type of switch	:	Snap acting magnetically operated hermetically sealed
13.	Switch configuration	:	2 SPDT (5A, 240 V AC, 0.5A, 220V DC)
14.	Accessories	:	a) Counter flange, nuts & bolts, suitable gasket etc. b) Steel globe type drain valve c) ½"NPT cable gland

			d)	Stainless steel nameplate with alpha-numeric engraved for service and tag
	15. Application	:	During Detail Engineering on Owner's approval	

3.04.00 FLOW SWITCH

1.	Type	:	Paddle /Piston/Disk	
2.	Wetted part material	:	Stainless steel or Hastelloy for acidic application	
3.	End connection	:	a)	Threaded upto 1" line size with integral Tee
		:	b)	Flanged for line size > 1 ½"
4.	Enclosure material	:	Stainless Steel	
5.	Enclosure class	:	IP 65	
6.	Switch configuration	:	2 SPDT (5A, 240 V AC, 0.5A, 220V DC)	
7.	Repeatibility	:	2%	
8.	Cable connection	:	½"NPTF	
9.	Accessories	:	a)	Tee, Counter flange, nuts & bolts, suitable gasket etc
			b)	½"NPT cable gland
			c)	Stainless steel nameplate with alpha-numeric engraved for service and tag

3.05.00 RF LEVEL SWITCH

1.	Type	:	RADIO FREQUENCY
	Sensing probe		
2.	Material	:	SS-316
3.	Mounting	:	Threaded
4.	Application Temperature	:	250°C (Max.)
	Electronic Controller		
5.	Input Supply Voltage	:	240V AC ±10%, 50 Hz.
6.	Relay Output	:	2 SPDT (240V AC, 5A)
7.	Ambient Temperature	:	50 °C
8.	Enclosure Protection	:	IP-66
9.	Enclosure Housing	:	SS
10.	Local LED Indication	:	Normal Level Power On Alarm Level Probe Healthy
11.	Switching Repeatability	:	±0.5%
12.	Accessories	:	Co-axial cable for probe connection to controller SS Tag plate ½" NPT Cable Glands
13.	Application	:	Solid level

3.06.00 CONDUCTIVITY TYPE LEVEL SWITCH

1.	Type	:	Conductivity discrimination
2.	Probe MOC	:	SS-316
3.	Mounting	:	Flanged on external cage
4.	Application Temperature	:	250°C (Max.)
5.	Test Pressure	:	Two times rated pressure

	6. Input Supply Voltage	:	240V AC ±10%, 50 Hz.
	7. Input	:	Four independent channel with selectable switching threshold for water conductivity
	8. Relay Output	:	2 SPDT (240V AC, 5A)
	9. Ambient Temperature	:	50 °C
	10. Enclosure Protection	:	IP-65 (Explosion proof for NEC Class-1, Division-1 area)
	11. Enclosure Housing	:	SS
	12. Local LED Indication	:	HI,LO, HIGH-HIGH, LOW-LOW Power Fault
	13. Accessories	:	a) Interconnecting cable from probe to electronics b) Mounting accessories c) External cage d) Washer & Gasket e) ½" NPT Cable Glands f) SS Tag Plate
	14. Application	:	During Detail Engineering on Owner's approval

3.07.00 TEMPERATURE SWITCH

	1. Type	:	Bimetallic or gas filled
	2. Sensing Element Material	:	SS-316
	3. Bulb Material	:	SS-316
	4. Capillary	:	Stainless Steel armored

approval

4.00.00 LOCAL INSTRUMENTS

4.01.00 PRESSURE GAUGE AND DIFFERENTIAL PRESSURE GAUGE

1.	Type	:	Bourdon/Bellows/Diaphragm
2.	Sensing & Socket	:	SS-316
3.	Movement Material	:	SS-316
4.	Case Material	:	Stainless steel. IP-65 (Explosion proof for NEC Class-1, Division 1 area)
5.	Dial Size	:	Generally 150 mm
6.	Scale	:	Black lettering on white in 270 O arc.
7.	Window	:	Shatterproof glass
8.	Range Selection	:	Normal process pressure: 50~70 % of range
9.	Over-range Protection	:	125% of maximum range by internal stop. External stop at zero
10.	Adjustment	:	For Zero adjustment (Micrometer screw external) For Range adjustment (Micrometer screw internal).
11.	Element Connection	:	Argon welding
12.	Process Connection	:	1/2" NPT (M) Bottom for local, back for panel mounting
13.	Performance	:	Accuracy of $\pm$ 1.0 % of span or better
14.	Operating ambient	:	0 - 50 ^{O}C
15.	Safety Feature	:	Blow out disc /diaphragm at the back
16.	Accessories	:	a) Snubbers for pulsating fluid application.discharge b) Stainless steel Diaphragm seals

			for corrosive/ viscous/ solid bearing or slurry type fluid applications
		c)	3-Way SS316 Gauge cock for pressure gauges
		d)	5-valve SS316 manifold from barstock for differential pressure gauge
		e)	Siphons for steam and hot water services
	17. Nameplate	:	Tag number, service engraved in stainless steel tag plate

4.02.00 LEVEL INDICATOR (FLOAT & BOARD TYPE)

1.	Type	:	Float and Board
2.	Float Material	:	SS-316
3.	Float Cable	:	SS-316
4.	Indicator Assembly	:	Epoxy painted Aluminium
5.	Guide wire spring assembly	:	SS-316 (2 Nos.)
6.	Guide Wire Anchor	:	SS-316
7.	Scale Board	:	Anodized Aluminium with engraved marking (Minimum graduation 10mm), mounting brackets and suitable hardware required as per tank height
8.	Elbow Assembly	:	Anodized Aluminium
9.	Flanges	:	RF , ANSI 150 , SS (3 Nos.)
10.	Accuracy	:	$\pm$ 10 mm or better
11.	Accessories	:	All mounting accessories including counter flange, nuts & bolts, suitable

gasket etc. as applicable, SS Tag plate

4.03.00 GAUGE GLASS

1.	Type	:	Reflex /Transparent
2.	Material		
	Glass	:	Toughened borosilicate resistant to thermal shock
	Body Material	:	~~Carbon Steel~~ Stainless Steel
	Enclosure	:	IP-65 (Explosion proof for NEC Class-1, Division 1 area)
3.	Integral cocks & valves/Fittings	:	i. SS 316
4.		:	ii. Rubber lined corrosion resistant stainless steel (for DM/RO service)
5.	Vessel Connection	:	ANSI Flanged SS316
6.	Accessories	:	i. Integral cocks ii. Drain Valves iii. Companion Flanges, Bolts, nuts, gaskets, SS Tag plate iv. Illuminating lamps, Mica shield as required v. Calibrated scale
7.	Pressure rating	:	Twice the maximum working pressure
8.	Temperature	:	300 ^{O} C
9.	Other details	:	For larger lengths (greater than 1200mm), additional gauge glasses shall be provided with minimum of 50 mm overlap.

			Head of TE to be provided with sufficient space and arrangement to mount head mounted temperature transmitter (as applicable).
7.	Accessories	:	a) Adjustable nipple-union-nipple [1/2" Sch 80 X ½" NPT] with thermowell connection b) Compression fittings/unions c) Flanges etc. (for flanged connections only) d) Thermowell (As specified below)
8.	Thermowell connection	:	½" NPT (M) or 150 RF Flanged
9.	Nameplate	:	Tag number, service engraved in stainless steel tag plate

5.03.00 TEMPERATURE GAUGE

1.	Type	:	Expansion type (Liquid filled system)
2.	Sensing Element Material	:	Bourdon – SS-316
3.	Bulb and Capillary Material	:	SS-316
4.	Capillary Tubing	:	Inner sheath - solid drawn Material copper tube Outer sheath - PVC tube
5.	Movement Materials	:	Stainless Steel / Direct Bourdon tip connection to pointer spindle
6.	Case Material	:	Stainless Steel stove enameled, black finish, threaded bezel ring, clear glass

			cover conforming to IP 65.
7.	Dial size	:	150 mm
8.	Scale	:	Black lettering on white background in 270 Deg.C arc
9.	Over range protection	:	125 percent of FSD
10.	Capillary Glanding	:	1/2" NPT(M) x compression fitting (SS) to suit capillary
11.	Instrument Connection	:	Bottom connection for local mounting, back connection for panel mounting
12.	Process Connection	:	½" NPT (M) or 150 RF Flanged
13.	Extension Neck Length	:	50 mm
14.	Compensation	:	a) Capillary compensation
15.		:	b) Case compensation
16.	Performance	:	a) Accuracy : + /- 1.0 percent of full scale Deflection
		:	b) Repeatability : Less than 0.5 percent of full range
		:	c) Response time: 15 seconds (max.).
17.	Capillary length	:	3.0 meters (local) / 15.0 metres (local panel)
18.	Other features	:	Shatter proof glass
19.	Nameplate	:	Tag number, service engraved in stainless steel tag plate
20.	Accessories	:	SS316 Thermowell

5.04.00 THERMOWELL

1.	Material	:	SS-316
2.	Manufacture	:	Drilled from bar stock, Hex Head, Tapered design (As per ASME PTC 19.3)

3.	Process connection	:	M33x2
4.	Certification	:	Not applicable
5.	Bore concentricity	:	+5% of wall thickness
6.	Identification mark	:	Tag number punched on head
7.	Surface treatment	:	Polish after machining
8.	Element connection	:	½" NPT (M) or 150 RF Flanged
9.	Head	:	Hex
10.	Length of the hex head	:	31.75 mm (min.)
11.	Accessories	:	SS Plug and chain for test thermo wells SS Nameplate, Flange with companion flange & all required accessories for flanged connections.

Note: Wake frequency calculations shall be furnished for all thermowells for approval.

Thermowells shall be designed such that the resonant frequency is above the exciting frequencies generated by vortex shedding in the process fluid.

5.05.00 METAL TEMPERATURE THERMOCOUPLE

1.	Measuring medium	:	Metal temperature
2.	Type	:	Chromel Alumel (Type-K) Duplex, Ungrounded
3.	Insulation	:	Mineral Insulation Magnesium Oxide
4.	Wire gauge	:	16 AWG
5.	Protective sheath	:	SS
6.	Protective sheath diameter	:	8 mm O.D.
7.	Characteristics	:	Special limits of error as in ANSI thermocouple MC 96.01
8.	Accessories	:	½" BSP SS sliding end connector, weld pad, clamps of heat resistant steel

QAP FOR INSTRUMENTS

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR FLOW SWITCH

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	100%	APPROVED SPEC./ DATA SHEETS	P	W	V	
	TYPE						
	RANGE						
	MODEL / TAG No.						
	END CONNECTION						
	DIMENSIONS						
	SIZE						
2	ACCURACY & REPEATABILITY (WET CALIBRATION)	100%		P	W	V	
3	HV / IR	100%		P	W	V	
4	CONTACT RATING / No. OF CONTACTS	RANDOM		P	W	V	
5	MATERIAL TC FOR BODY, WET PARTS, SENSING ELEMENT	ONE / LOT		P	W	V	
6	ACCESSORIES AS APPLICABLE	100%		P	W	V	
7	DEGREE OF PROTECTION	ONE / LOT		P	W	V	
8	OVER PRESSURE TEST	100%		P	W	V	

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL, P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. Manufacturer to carry out routine test for 100%
4. Contractor to provide compliance certificate for tests/checks verifid by contractor and submit the same alongwith test certificates to be verified by BHEL.

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR TEMPERATURE SWITCH

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	100%	APPROVED SPEC./ DATA SHEETS	P	W	V	
	TYPE						
	MODEL/TAG NO.						
	RANGE/SCALE						
	END CONNECTION						
2	DIMENSIONS CHECK	100%		P	W	V	
3	ACCURACY	100%		P	W	V	
4	SWITCHING DIFFERENTIAL	100%		P	W	V	
5	CONTACT RATING / No. OF CONTACTS	RANDOM		P	W	V	
6	MATERIAL TC FOR BULB, CAPILLARY, ARMOUR	ONE / LOT		P	V	V	
7	HV / IR	RANDOM		P	W	V	
8	DEGREE OF PROTECTION	TYPE TEST		P	V	V	
9	THERMOWELLS						
	DIMENSIONS,PROCESS CONN	100%		P	W	V	
	MATERIAL TC	ONE / LOT		P	V	V	
	HYD TEST	100%		P	W	V	
	IBR CERTIFICATE, IF APPLICABLE			P	V	V	
10	REPEATABILITY	100%		P	V	V	
11	HYSTERISIS	100%		P	V	V	
12	ACCESSORIES AS APPLICABLE	SEE NOTE-1 BELOW		P	W	V	

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL, P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. Contractor to provide compliance certificate for tests/checks verifid by contractor and submit the same alongwith test certificates to be verified by BHEL.
4. Manufacturer to carry out routine test for 100%

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR PRESSURE SWITCH

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	SEE NOTE-1 BELOW	APPROVED SPEC./ DATA SHEETS	P	V	V	
	1.1 MODEL NO/TAG NO						
	1.2 RANGE						
	1.3 END CONN						
	1.4 NO. OF CONTACT						
2	CALIBRATION			P	V	V	
	2.1 REPEATABILITY						
	2.2 SET POINT ADJUSTMENT						
	2.3 DIFFERENTIAL						
3	OVER PR & LEAK TEST			P	V	V	
4	ELECT. INSULATION/HV TEST	ONE		P	V	V	
5	REVIEW OF TC FOR MATERIALS OF	FOR LOT		V	V	V	
	5.1 SENSOR						
	5.2 MOVEMENT						
	5.3 PROCESS CONNECTION						
	5.4 HOUSING						
6	REVIEW OF TC FOR DEGREE OF PROTECTION	TYPE TEST		V	V	V	
7	REVIEW OF TC OF MICROSWITCH	FOR LOT		V	V	V	

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL,
P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to carry out ROUTINE TEST on 100 %.
3. Contractor to provide compliance certificate for tests/checks verifid by contractor and the same alongwith test certificates to be verified by BHEL

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR FLOAT OPERATED LEVEL SWITCH

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	SEE NOTE-1 BELOW	APPROVED SPEC./ DATA SHEETS	P	V	V	
	MODEL NO/TAG NO						
	TYPE						
	END CONNECTION						
2	ON/OFF DIFFL			P	W	V	
3	REPEATABILITY			P	W	V	
4	IR TEST			P	W	V	
5	HV TEST			P	V	V	
6	PR. TEST ON CHAMBER	SEE NOTE-5		P	V	V	
7	MATL. TC FOR CHAMBER & FLOAT	FOR LOT	---	V	V	V	
8	CONTACT CONFIG. & RATING FOR MICROSWITCH	FOR LOT	---	V	V	V	
9	TC FOR DEGREE OF PROTECTION	TYPE TEST	---	V	V	V	
10	MANUFACTURER TO ENSURE WELDING PROCEDURE,WELDERS & NDT AS PER ASME FOR PR >40 KG/CM2		---	P	V	V	
11	CHECK FOR TEMP. SUITABILITY FOR MICROSWITCH AND LEAD WIRE	SEE NOTE-1 BELOW	---	V	V	V	
12	ACCESSORIES AS APPLICABLE		APPROVED SPEC./ DATA SHEETS	V	V	V	

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL, P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. Manufacturer to carry out ROUTINE TEST on 100 %.
4. When material corelation is not available, MFR's compliance to be provided
5. IBR certificates shall be provided wherever required.
6. Contractor to provide compliance certificate for tests/checks verifid by contractor and the same alongwith test certificates to be verified by BHEL

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR ANALYTICAL INSTRUMENTS

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	SEE NOTE-1 BELOW	APPROVED SPEC./ DATA SHEETS	P	V	V	
	VISUAL						
	MAKE, MODEL No.						
	POWER SUPPLY						
	TYPE						
2	DIMENSIONS CHECK			P	V	V	
3	FUNCTIONAL CHECK			P	V	V	
4	LEAKAGE TEST			P	V	V	
5	HV / IR TEST			P	V	V	
6	LINEARITY			P	V	V	
7	RESPONSE TIME			P	V	V	
8	ENCLOSURE CLASS			P	V	V	
9	ACCESSORIES, AS APPLICABLE			P	V	V	
10	ACCURACY / CALIBRATION			P	V	V	
11	ALARM CONTACT TEST			P	V	V	
12	ANALOG OUTPUT CHECK			P	V	V	
13	BURN-IN TEST OF ELECTRONIC PARTS	1/LOT		P	V	V	
14	IN-BUILT INDICATOR, ZERO, SPAN, RANGE SCALE SELECTION ETC	SEE NOTE-1 BELOW		P	V	V	

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL,
P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. Contractor to provide compliance certificate for tests/checks verifid by contractor and submit the same alongwith test certificates to be verified by BHEL.

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR ANNUNCIATORS

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	SEE NOTE-1 BELOW	APPROVED SPEC./ DATA SHEETS	P	W	V	
	TYPE/ MODEL						
	DIMENSIONS OF HARDWARE						
	MODULARITY						
	SEQUENCE						
	FACIA DETAILS						
2	FUNCTIONAL TEST	100%		P	W	V	
3	IMMUNE TO STEP VARIATIONS IN THE POWER SUPPLY	SEE NOTE-1 BELOW		P	W	V	
4	DEGREE OF PROTECTION FOR ENCLOSURE	TYPE TEST		P	W	V	
5	I/R CHECK	SEE NOTE-1 BELOW		P	W	V	
6	RESPONSE			P	W	V	

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL,
P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. Manufacturer to carry out ROUTINE TEST on 100 %.
4. Contractor to provide compliance certificate for tests/checks verifid by contractor and submit the same alongwith test certificates to be verified by BHEL.

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR TRANSMITTER

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECKS FOR	SEE NOTE-1 BELOW	APPROVED SPEC./ DATA SHEETS	P	W	V	
	VISUAL.						
	MODEL/TAG No						
2	PROCESS CONNECTION			P	W	V	
3	ACCURACY			P	W	V	
4	REPEATABILITY			P	W	V	
5	HYSTERESIS			P	W	V	
6	EFFECT OF TEMP VARIATION ON ACCURACY			P	W	V	
7	SPAN / ZERO ADJUSTMENT	ONE / TYPE		P	W	V	
8	EFFECT OF SUPPLY VOLTAGE VARIATION			P	W	V	
9	EFFECT OF LOADING (500 OHM METERS)			P	W	V	
10	HIGH PRESSURE TEST	SEE NOTE-1 BELOW		P	W	V	
11	BURN-IN TEST	ONE / TYPE		P	W	V	
12	DEGREE OF PROTECTION			P	W	V	
13	ACCESSORIES AS APPLICABLE	SEE NOTE-1 BELOW		V	V	V	

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL,
P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. When material corelation are not available manufacturer's compliance to be provided.
4. Contractor to provide compliance certificate for tests/checks verifid by contractor and submit the same alongwith test certificates to be verified by BHEL.

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR TEMPERATURE ELEMENT

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	SEE NOTE-1 BELOW	APPROVED SPEC./ DATA SHEETS	P	W	V	
	TYPE						
	MODEL No./TAG No.						
	PROCESS CONNECTION						
2	STABILITY			P	W	V	
3	INSULATION RESISTANCE			P	W	V	
4	ENCLOSURE CLASS			P	W	V	
5	RESPONSE TIME			P	W	V	
7	ACCURACY			P	W	V	
8	HYDROSTATIC TEST			P	W	V	
9	ELECTRICAL CHARACTERISTIC OF SENSOR (CONTINUTY OF T/C WIRES & INSULATION RESISTANCE OF RTD LEADS w.r.t. BODY			P	W	V	
10	TEMP CURVES / CHARTS			P	V	V	
11	AMBIENT TEMP. EFFECT CHECK			P	W	V	
12	HV TEST			P	W	V	

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL,
P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. Contractor to provide compliance certificate for tests/checks verifid by contractor and submit the same alongwith test certificates to be verified by BHEL.
4. IBR certificate to be provided, if applicable

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR MAGNETIC TYPE FLOW METER

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	SEE NOTE-1 BELOW	APPROVED SPEC./ DATA SHEETS	P	W	V	
	MODEL						
	TAG No						
	VISUAL						
2	DIMENSIONS,			P	W	V	
3	PROCESS CONNECTION			P	W	V	
4	RANGE / SCALE			P	W	V	
5	ACCURACY			P	W	V	
6	MATERIAL TC FOR METERING TUBE, ORIFICE PLATE, FLANGES AND FASTNER			P	V	V	
7	CALIBRATION REPORT	ONE / SIZE		P	V	V	
8	ACCESSORIES AS APPLICABLE	SEE NOTE-1 BELOW		V	V	V	
9	TC FOR DEGREE OF PROTECTION	TYPE TEST		V	V	V	

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL, P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. Manufacturer to carry out ROUTINE TEST on 100 %.
4. Contractor to provide compliance certificate for tests/checks verifid by contractor and the same alongwith test certificates to be verified by BHEL

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR SOLENOID VALVES

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	SEE NOTE-1 BELOW	APPROVED SPEC./ DATA SHEETS	P	W	V	
	TYPE						
	MAKE						
	MODEL No.						
2	MATERIAL (BODY. PLUNGER/TRIM)			P	W	V	
3	PORT SIZE			P	W	V	
4	CABLE CONNECTION SIZE			P	W	V	
5	ENCLOSURE CLASS			P	W	V	TYPE TEST CERTIFICATE TO BE FURNISHED BY VENDOR
6	No. OF COILS & INSULATION CLASS			P	W	V	TEST CERTIFICATE TO BE FURNISHED FOR INSULATION CLASS BY VENDOR
7	POWER SUPPLY CHECK			P	W	V	
8	IR / HV TEST			P	W	V	
9	FUCTIONAL TEST			P	W	V	

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL,
P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. Contractor to provide compliance certificate for tests/checks verifid by contractor and submit the same alongwith test certificates to be verified by BHEL.

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR TEMPERATURE GAUGE

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	SEE NOTE-1 BELOW	APPROVED SPEC./ DATA SHEETS	P	W	V	
	DIAL SIZE						
	MODEL NO./TAG NO./TYPE						
	RANGE/SCALE						
	END CONNECTION						
2	CALIBRATION			P	W	V	
	ACCURACY						
	REPEATABILITY						
	HYSTERESIS						
3	OVER TEMP. TEST			P	W	V	
4	AMBIENT TEMP. COMPENSATION CHECK	1 OF TYPE		P	V	V	
5	REVIEW OF TC FOR MATERIALS OF	FOR LOT		V	V	V	
	SENSOR						
	MOVEMENT						
	PROCESS CONNECTION						
	THERMOWELL						
	HOUSING						
6	REVIEW OF TC FOR DEGREE OF PROTECTION	TYPE TEST		V	V	V	
7	THERMOWELL	SEE NOTE-1 BELOW	AS PER APPD DWG		V	V	
	MATERIAL TC & DIMN. CHECK						
	HYD.TEST						
	OVER RANGE TEST						

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL,
P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. Manufacturer to carry out ROUTINE TEST on 100 %.
4. IBR certificate to be provided if called for in specn.
5. Contractor to provide compliance certificate for tests/checks verifid by contractor and submit the same alongwith test certificates to be verified by BHEL.

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR PRESSURE & DP GAUGE

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	SEE NOTE-1 BELOW	APPROVED SPEC./ DATA SHEETS	P	W	V	
	SENSOR TYPE						
	DIAL SIZE						
	MODEL NO/TAG NO						
	RANGE/SCALE						
	SWITCH CONTACT RATING & NOS.						
	END CONNECTION						
2	CALIBRATION			P	W	V	
	ACCURACY						
	REPEATABILITY						
	SET POINT ADJUSTMENT						
3	OVER PRESSURE & LEAK TEST			P	W	V	
4	OPERATION OF PRESSURE. RELIEF DEVICE	ONE		P	W	V	
5	REVIEW OF TC FOR	FOR LOT		V	V	V	
	MATERIALS OF SENSOR						
	MOVEMENT						
	PROCESS CONNECTION						
	HOUSING						
6	REVIEW OF TC FOR DEGREE OF PROTECTION	TYPE TEST		V	V	V	
7	ACCESSORIES AS APPLICABLE	SEE NOTE-1 BELOW		V	V	V	

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL, P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. Manufacturer to carry out ROUTINE TEST on 100 %.
4. When material corelation is not available, MFR's compliance to be provided
5. Contractor to provide compliance certificate for tests/checks verifid by contractor and submit the same alongwith test certificates to be verified by BHEL.

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR LEVEL GAUGE

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	SEE NOTE-1 BELOW	APPROVED SPEC./ DATA SHEETS / DRWGS	P	W	V	
	TYPE						
	MODEL/ TAG NO.						
	DAIL SIZE						
	RANGE/SCALE						
	END CONNECTION						
2	DIMENSIONS, PROCESS CONNECTION			P	W	V	
3	ACCURACY			P	W	V	
4	MATERIAL TC FOR	ONE / LOT		P	V	V	
	BODY ISO.						
	VALVE						
	GAUGE GLASS						
5	HYD. TEST	SEE NOTE-1 BELOW		P	W	V	
6	ACCESSORIES AS APPLICABLE			P	W	V	

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL, P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. Manufacturer to carry out ROUTINE TEST on 100 %.
4. Contractor to provide compliance certificate for tests/checks verifid by contractor and submit the same alongwith test certificates to be verified by BHEL.

STANDARD CHECK LIST FOR C&I INSTRUMENTS (for Maux Pkgs)

CHECK LIST FOR SIGHT FLOW INDICATOR

Sl. No.	Test / Checks	Quantum of check	Reference Doc. / Acceptance Norms	Agency **			Remarks
				M	C	B	
1	CHECK FOR	SEE NOTE-1 BELOW	APPROVED SPEC./ DATA SHEETS	P	W	V	
	MODEL						
	TAG No.						
	VISUAL						
2	DIMENSIONS,			P	W	V	
3	PROCESS CONNECTION			P	W	V	
4	RANGE / SCALE			P	W	V	
5	ACCURACY			P	W	V	
6	MATERIAL TC FOR METERING TUBE, ORIFICE PLATE, FLANGES AND FASTNER			P	V	V	
7	CALIBRATION REPORT	ONE / SIZE		P	V	V	
8	ACCESSORIES AS APPLICABLE	SEE NOTE-1 BELOW		V	V	V	
9	TC FOR DEGREE OF PROTECTION	TYPE TEST		V	V	V	

Legend :

** M = Manufacturer / Sub-contractor, C = Contractor / Nominated Inspecting Agency, B = BHEL, P = Perform, W = Witness, V = Verification

Note :

1. Quantum of check shall be as below :
   100 % - By Manufacturer
2. Manufacturer to maintain calibrated instrument having better accuracy than the item under test. Inspecting engineer shall check the same.
3. Manufacturer to carry out ROUTINE TEST on 100 %.
4. Contractor to provide compliance certificate for tests/checks verifid by contractor and the same alongwith test certificates to be verified by BHEL

BHEL	**5x800 MW TSGENCO YADADRI TPS** **CONTROL & INSTRUMENTATION** Technical specification for **NATURAL DRAFT COOLING TOWER**	SPEC NO.: **PE-TS-417-145-IXXX** VOLUME SECTION REV. NO. 00 | DATE : 20.07.2017 SHEET OF

ACTUATOR SPECIFICATION & DATA SHEET

VOLUME: V-A

SECTION-III

TECHNICAL SPECIFICATION FOR ELECTRIC MOTOR ACTUATORS

1.00.00 SCOPE

1.01.00 This Section covers the general requirements of Electric Motor Actuators for valves/dampers.

1.02.00 All electric motor actuators shall be furnished in accordance with this general specification and the accompanying driven equipment specification. All the electrical actuators shall be INTEGRAL type only.

2.00.00 STANDARDS

2.01.00 All electrical equipment shall conform to the latest applicable IS, ANSI and NEMA Standards, except when stated otherwise herein or in driven equipment specification.

2.02.00 Major standards, which shall be followed, are listed below. Other applicable Indian Standards for any component part even if not covered in the listed standards shall also be followed

i) IS-9334

ii) IS-325

3.00.00 SERVICE CONDITIONS

3.01.00 The actuator shall be suitable for operation in hot, humid and tropical atmosphere, highly polluted at places with coal dust and/or fly ash.

3.02.00 Unless otherwise noted, electrical equipment/system design shall be based on the service conditions and auxiliary power supply given in the general specification.

3.03.00 For actuator motor installed outdoor and exposed to direct sun rays, the effect of solar heat shall be considered in the determination of the design ambient temperature.

4.00.00 RATING

4.01.00 For isolating service, the actuator shall be rated for three successive open-close operation of the valve/damper or 15 minutes, whichever is longer.

4.02.00 For regulating service, the actuator shall be suitably time-rated for the duty cycle involved with necessary number of starts per hour, but in no case less than 150 starts per hour.

5.00.00 **PERFORMANCE**

The actuator shall meet the following performance requirements:

5.01.00 Open and close the valve completely and make leak-tight valve closure without jamming.

5.02.00 Attain full speed operation before valve load is encountered and imparts an unseating blow to start the valve in motion (hammer blow effect).

5.03.00 Operate the valve stem at standard stem speed and shall function against design differential pressure across the valve seat.

5.04.00 The motor reduction gearing shall be sufficient to lock the shaft when the motor is de-energised and prevent drift from torque switch spring pressure.

5.05.00 The entire mechanism shall withstand shock resulting from closing with improper setting of limit switches or from lodging of foreign matter under the valve seat.

6.00.00 **SPECIFIC REQUIREMENT**

6.01.00 **Construction**

6.01.01 The actuator shall essentially comprise the drive motor, torque/ limit switches, gear train, clutch, hand wheel, position indicator/ transmitter, in-built thermostat for over load protection, space heater and internal wiring.

6.01.02 The actuator enclosure shall be totally enclosed, dust tight, weather-proof suitable for outdoor use without necessity of any canopy. Degree of protection of enclosure for motor actuator shall be IP-65.

6.01.03 All electrical equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.

6.01.04 The actuator shall be designed for mounting in any position without any lubricant leakage or operating difficulty.

6.02.00 **Motor**

6.02.01 The drive motor shall be three phase, squirrel cage, induction machine with minimum class B insulation and IPW-55 enclosure, designed for high torque and reversing service. Canopy shall be provided for outdoor service.

6.02.02 The motor shall be designed for full voltage direct on-line start, with starting current limited to 6 times full-load current.

6.02.03 The motor shall be capable of starting at 85 percent of rated voltage and running at 80 percent of rated voltage at rated torque and 85 percent rated voltage at 33 percent excess rated torque for a period of 5 minutes each.

6.02.04 Motor leads shall be terminated in the limit switch compartment.

6.02.05 Motor actuators for valves/dampers shall be with integral starter with 3phase/3wire, 415V AC and operable from remote.

6.02.06 Earthing terminals shall be provided on either side of the motor.

6.03.00 **Limit Switches**

Each actuator shall be provided with following limit switches: -

6.03.01 2 torque limit switches, one for each direction of travel, self-locking, adjustable torque type.

6.03.02 4 end-of-travel limit switches, two for each direction of travel.

6.03.03 2 position limit switches, one for each direction of travel, each adjustable at any position from fully open to fully closed positions of the valve/damper.

6.03.04 Each limit switch shall have 2 NO + 2 NC potential free contacts. Contact rating shall be 5A at 240V A.C. or 0.5A at 220V D.C.

6.04.00 **Hand Wheel**

Each actuator shall be provided with a hand wheel for emergency manual operation. The hand wheel shall declutch automatically when the motor is energized.

6.05.00 **Position Indicator/Transmitter**

The actuator shall have:

6.05.01 One (1) built-in local position indicator for 0-100% travel.

6.05.02 One (1) position transmitter, 4-20 mA current signal as position feedback, for remote indicator.

6.06.00 **Space Heater**

A space heater shall be included in the limit switch compartment suitable for 240V, 1 phase, 50 Hz supply.

6.07.00 **Wiring**

All electrical devices shall be wired up to and terminated in a terminal box. All wiring shall be done with 1100V grade fire resistance PVC insulated stranded copper conductor of not less than 2.5 Sq.mm cross section. All wiring shall be identified at both ends with ferrules. All the electrical actuators shall have uniform wiring.

6.08.00 **Terminal Box**

The terminal box shall be weather proof, with removable front cover and cable glands for cable connection. The terminal shall be suitable for connection of 2.5 Sq.mm copper conductor.

7.00.00 **ACCESSORIES**

As required for the driven equipment, the actuator shall be furnished with starting equipment mounted on the actuator. This shall include:

7.01.00 One (1) triple pole MCCB

7.02.00 One (1) reversing starter with mechanically interlocked contactors, 3 thermal overload relays, 2 NO + 2 NC auxiliary contacts for each contactor.

7.03.00 One (1) remote-local selector switch.

7.04.00 CLOSE-STOP-OPEN oil tight push buttons with indication lights.

7.05.00 415/240 V control transformer with primary & secondary fuses.

8.00.00 **TEST**

The actuator and all components thereof shall be subject to tests as per relevant Standards. In addition, if any special test is called for in equipment specification, the same shall be performed.

9.00.00 **DRAWINGS, DATA & MANUALS**

9.01.00 Drawings, Data & Manuals shall be submitted in triplicate with the bid and in quantities and procedures as specified in General Conditions of Contract and/or elsewhere in the specification for approval and subsequent distribution after the issue of 'Letter of Intent'.

9.02.00 **To be submitted with Bid**

Data sheet for each type of actuator shall be furnished along with internal wiring diagram, suggested control schematic and torque limit switch contact development and manufacturer's catalogues. Drawings, Data & Manuals shall be submitted in triplicate with the bid and in quantities and procedures as specified in General Conditions of Contract and/or elsewhere in the specification for approval and subsequent distribution after the issue of 'Letter of Intent'.

9.03.00 **To be submitted for Owner / Purchaser's Approval and Distribution**

All relevant drawings and data pertaining to the equipment like GTP, GA drawing, foundation plan, BOM, control & schematics, QAP, etc. shall be submitted by the Bidder for approval of Owner/Owner's consultant. Also refer clause no. 1.19.02(u) of Section-I of Volume – V-A: Technical Specifications for Electrical Equipment & Accessories.

ANNEXURE-A

DESIGN DATA

1.0 AUXILIARY POWER SUPPLY

Supply		Description	Consumer
L.V. Supply	(i)	415V, 3Ø, 3W, 50 Hz Effectively earthed Fault level 50 kA symm. for 1 sec.	Motors above 0.2kW upto less than 175kW.
	(ii)	240V AC/415V AC	Motors upto 0.2kW.
		240V, 1Ø, 2W, 50 Hz effectively earthed	Lighting, Space heating , A.C supply for Control & protective devices.
D.C. Supply		220V, 2W, unearthed Fault level 25* kA. for 1 sec.	D.C. alarm, control & protective devices

* Indicative only, the actual value will be decided by the Bidder, after substantiating the same by calculation.

2.0 RANGE OF VARIATION

A.C. Supply :

Voltage	:	± 10%
Frequency	:	+3% to -5%.
Combined Volt + frequency	:	10% (absolute sum)

During starting of large motor, the voltage may drop to 80% of the rated voltage for a period of 60 seconds. All electrical equipment while running shall successfully ride over such period without affecting system performance.

D.C. Supply :

Voltage	:	187 to 242

FORM NO. PEM-6666-0

	SPECIFICATION FOR MOTORISED VALVE ACTUATOR	SPECIFICATION NO.:
		VOLUME
		SECTION
		REV. NO. 00 | DATE: 06.01.2015
		SHEET 1 OF 3

Data Sheet A & B

	DATA SHEET-A (TO BE FILLED BY PURCHASER)	DATA SHEET-B (TO BE FILLED-UP BY BIDDER)
GENERAL*	* PROJECT	5X800 MW YADADRI TPS
	OFFER REFERENCE	
	* TAG NO. SERVICE	
	* DUTY	☐ ON / OFF ☐ INCHING
	* LINE SIZE (inlet/outlet): MATERIAL	
	* VALVE TYPE	☐ GLOBE ☐ GATE ☐ REG. GLOBE ☐ BUTTERFLY
	* OPENING / CLOSING TIME	
	* WORKING PRESSURE	
	AMBIENT CONDITION	SHALL BE SUITABLE FOR CONTINUOUS OPERATION UNDER AN AMBIENT TEMP. OF 0-55 DEG C AND RELATIVE HUMIDITY OF 0-95%
	VALVE SEAT TEST PRESS	BIDDER TO SPECIFY
	REQUIRED VALVE TORQUE	BIDDER TO SPECIFY
	ACTUATOR RATED TORQUE	BIDDER TO SPECIFY
CONSTRUCTION AND SIZING	CONSTRUCTION	TOTALLY ENCLOSED, DUST TIGHT, WEATHER PROOF,SUITABLE FOR OUTDOOR USE WITHOUT CANOPY, IP:65
	MECHANICAL POSITION INDICATOR	TO BE PROVIDED FOR 0-100% TRAVEL
	BEARINGS	DOUBLE SHIELDED, GREASE LUBRICATED ANTI-FRICTION.
	GEAR TRAIN FOR LIMIT SWITCH/TORQUE SWITCH OPERATION	METAL (NOT FIBRE GEARS). SELF-LOCKING TO PREVENT DRIFT UNDER TORQUE SWITCH SPRING PRESSURE WHEN MOTOR IS DE-ENERGIZED.
	SIZING	OPEN/CLOSE AT RATED SPEED AGAINST DESIGNED DIFFERENTIAL PRESSURE AT 90% OF RATED VOLTAGE. FOR ISOLATING SERVICE THREE SUCCESSIVE OPEN-CLOSE OPERATIONS OR 15 MINS. WHICHEVER IS HIGHER. FOR REGULATING SERVICE - 150 STARTS/HR MINIMUM
HANDWHEEL	* REQUIRED	■ YES ☐ NO
	* ORIENTATION	☐ TOP MOUNTED ☐ SIDE MOUNTED
	*TO DISENGAGE AUTOMATICALLY DURING MOTOR OPERATION.	
ELECTRIC ACTUATOR	ACTUATOR MAKE/MODEL	BIDDER TO SPECIFY
	MOTOR MAKE / MODEL / TYPE / RATING (KW)	BIDDER TO SPECIFY
	@ MOTOR TYPE	SQUIRREL CAGE INDUCTION MOTOR, STARTING CURRENT LIMITED TO SIX TIMES THE FULL LOAD CURRENT-INCLUSIVE OF **I.S.** TOLERANCE
	ACTUATOR APPLICABLE WIRING DIAGRAM	■ ENCLOSED ■ DRG. NO. 3-V-MISC-24227 R00 (INDICATIVE)
	COLOUR SHADE	■ BLUE (RAL 5012), To be decided during detail engg.
	PAINT TYPE **(## Refer Notes)**	☐ ENAMEL ■ EPOXY ☐ …….
	SHAFT RPM	BIDDER TO SPECIFY
	OLR SET VALUE	BIDDER TO SPECIFY
	@ STARTING / FULL LOAD CURRENT	BIDDER TO SPECIFY
	NO. OF REV FOR FULL TRAVEL	BIDDER TO SPECIFY
	@ PWR SUPP TO MTR / STARTER	415V, 3PH, AC
	@ CONTROL VOLTAGE REQUIREMENT	TO BE DERIVED FROM THE POWER SUPPLY TO THE STARTER ☐ 230 V ☐ 110 V (BIDDER TO SPECIFY SINCE INTEGRAL STARTER IS ENVISAGED)

	SPECIFICATION FOR MOTORISED VALVE ACTUATOR	SPECIFICATION NO.:
		VOLUME
		SECTION
		REV. NO. 00 DATE: 06.01.2015
		SHEET 2 OF 3

Data Sheet A & B

		DATA SHEET-A (TO BE FILLED BY PURCHASER)	DATA SHEET-B (TO BE FILLED-UP BY BIDDER)
	@ ENCLOSURE CLASS OF MOTOR	■ IP 65 ☐ FLAME PROOF	
	@ INSULATION CLASS	CLASS-F TEMP. RISE LIMITED TO CLASS-B	
	@ WINDING TEMP PROTECTION	■ THERMOSTAT (3 Nos.,1 IN EACH PHASE) ☐ ----------	
	SINGLE PHASE / WRONG PHASE SEQUENCE PROTECTION	REQUIRED	
INTEGRAL STARTER	INTEGRAL STARTER	■ REQUIRED ☐ NOT REQUIRED	
	TYPE OF SWITCHING DEVICE	■ CONTACTORS ☐ THYRISTORS	
	TYPE	■ CONVENTIONAL ☐ SMART (NON-INTRUSIVE)	
	IF SMART	NOT APPLICABLE	
	a) SERIAL LINK INTERFACE	☐ INTEGRAL ☐ FIELD MOUNTED	
	b) SERIAL LINK PROTOCOL	☐ FOUNDATION FIELD-BUS ☐ PROFI-BUS ☐ DEVICE NET ☐.....	
	c) SERIAL LINK MEDIA	☐ TWISTED PAIR Cu-CBL ☐ CO-AXIAL Cu-CBL ☐ OFC	
	d) HAND HELD PROGRAMMER	☐ REQUIRED ☐ NOT REQUIRED	
	e) TYPE OF HAND HELD PROGRAMMER	☐ BLUETOOTH ☐ INFRARED ☐.....	
	f) MASTER STATION	☐ REQUIRED ☐ NOT REQUIRED	
	g) MASTER STN INTRFACE WITH DCS	☐ MODBUS ☐ TCP/IP	
	h) DETAILS OF SPECIAL CABLE	☐ ENCLOSED ☐ NOT REQUIRED	
	STEP DOWN CONT. TRANSFORMER	■ REQUIRED	
	OPEN / CLOSE PB	■ REQUIRED ☐ NOT REQUIRED	
	STOP PB	■ REQUIRED ☐ NOT REQUIRED	
	INDICATING LAMPS	■ REQUIRED ☐ NOT REQUIRED	
	LOCAL REMOTE S/S	■ REQUIRED ☐ NOT REQUIRED	
	STATUS CONTACTS FOR MONITORING	■ REQUIRED ☐ NOT REQUIRED	
	INTEGRAL STARTER DISTURBED SIGNAL	REQUIRED (O/L RELAY OPERATED, CONT. /POWER SUPPLY FAILED, S/S IN LOCAL, TORQUE SWITCH OPTD. MID WAY)	
INTERPOSING RELAY/OPTO COUPLER (Applicable for integral Starter)	TYPE OF ISOLATING DEVICE	■ INTERPOSING RELAY ☐ OPTO COUPLER ☐ EITHER	
	QUANTITY	■ 2 NOs. ☐ 3 NOs.	
	DRIVING VOLTAGE	■ 20.5 – 24V DC ☐ _____V DC	
	DRIVING CURRENT	■ 125mA MAX ☐ _____mA MAX	
	LOAD RESISTANCE	■ > 192 ohms - <25 k ohms ☐ > _____ohms - < _____ohms	
TORQUE SWITCH (Not Applicable for Smart Actuator) **($$ Refer Notes)**	MFR & MODEL NO.	BIDDER TO SPECIFY	
	OPEN / CLOSE	■1 No. ☐2Nos. / ■1 No. ☐2Nos	
	CONTACT TYPE	2 NO + 2 NC	
	RATING	5A 240V AC AND 0.5A 220V DC	
	CALIBRATED KNOBS(OPEN&CLOSE TS)	REQUIRED FOR SETTING DESIRED TORQUE	
	ACCURACY	+3% OF SET VALUE	
LIMIT SWITCH (Not Applicable for Smart Actuator) **($$ Refer Notes)**	MFR & MODEL NO.	BIDDER TO SPECIFY	
	OPEN : INT : CLOSE	☐1 No ■2 Nos. / 2 Nos. (ADJ.) / ☐1 No. ■2Nos.	
	CONTACT TYPE	2 NO + 2 NC	
	RATING (AC / DC)	5A 240V AC AND 0.5A 220V DC	

FORM NO. PEM-6666-0

BHEL	**SPECIFICATION FOR MOTORISED VALVE ACTUATOR**	SPECIFICATION NO.:
		VOLUME
		SECTION
		REV. NO. 00 DATE: 06.01.2015
		SHEET 3 OF 3

Data Sheet A & B

	DATA SHEET-A (TO BE FILLED BY PURCHASER)		DATA SHEET-B (TO BE FILLED-UP BY BIDDER)
POSITION TRANSMITTER	POSITION TRANSMITTER	■ REQUIRED ☐ NOT REQUIRED	
	MFR & MODEL NO.	BIDDER TO SPECIFY	
	TYPE	☐ ELECTRONIC (2 WIRE) R/I CONVERTER ■ ELECTRONIC (2 WIRE) CONTACTLESS	
	SUPPLY	■ 24V DC ☐	
	OUTPUT	■ 4-20mA	
	ACCURACY	± 1% FS	
SPACE HEATER	@SPACE HEATER	REQUIRED	
	@ POWER SUPPLY (NON INTEGRAL)	240V AC,1 PH.,50 Hz	
	@ POWER SUPPLY (INTEGRAL)	BIDDER TO SPECIFY	
	@ RATING	BIDDER TO SPECIFY	
TERMINAL BOX	ACTUATOR/MOTOR TERMINAL BOX	REQUIRED	
	ENCL CLASS ACTUATOR/MOTOR T.B.	@☐ IP 68 @☐.....	
	@ EARTHING TERMINAL	REQUIRED	
	PLUG & SOCKET(9 PIN) (FOR COMMD, LS/TS FEED BACK, PoT)	☐ REQUIRED ■ NOT REQUIRED ☐ 2 NOS. ☐ ----------	
CABLE GLANDS	@ POWER CABLE GLAND	SIZE: DURING DETAILED ENGINEERING	
	@ SPACE HEATER CABLE GLAND	SIZE: NOT REQUIRED	
	OTHER CONTROL CABLE GLANDS-1	REFER NOTE &&	
	OTHER CONTROL CABLE GLANDS-2	QUANTITY & SIZE:	
WEIGHT	TOTAL WEIGHT (ACTUATOR + ACCESSORIES)	BIDDER TO SPECIFY	_____ Kg.

NOTES:

1. **SCOPE**: DESIGN, MANUFACTURE, INSPECTION, TESTING AND DELIVERY TO SITE OF ELECTRIC ACTUATOR FOR INCHING OR OPEN / CLOSE DUTY.
2. **CODES & STANDARDS**: DESIGN AND MATERIALS USED SHALL COMPLY WITH THE RELEVANT LATEST NATIONAL AND INTERNATION STANDARD. AS A MINIMUM, THE FOLLOWING STANDARDS SHALL BE COMPLIED WITH:
   IS-9334, IS-2147, IS-2148, IS-325, IS-2959, IS-4691 AND IS-4722
3. TEMPERATURE RISE SHALL BE RESTRICTED TO 70 DEG. C FOR AMBIENT TEMPERATURE OF 50 DEG C.
4. CABLE GLANDS OF DOUBLE COMPRESSION TYPE, BRASS MATERIAL, WITH NICKEL COATING SHALL BE PROVIDED.
5. THE TORQUE SWITCHES SHALL BE PROVIDED WITH MECHANICAL LATCHING DEVICE TO PREVENT OPERATION WHEN UNSEATING FROM THE END POSITIONS. THE LATCHING DEVICE SHALL UNLATCH AS SOON AS THE VALVE LEAVES THE END POSITION. IF SUCH PROVISION IS NOT POSSIBLE, THE TORQUE SWITCHES SHALL BE BYPASSED BY END-POSITION LIMIT SWITCHES WHICH OPENS ON VALVE LEAVING END POSITION.THESE LIMIT SWITCHES ARE ADDITIONAL TO THE NUMBER OF LIMIT SWITCHES SPECIFIED ELSEWHERE.
6. THE MOTOR SHALL OPERATE SATISFACTORILY UNDER THE +/- 10% SUPPLY VOLTAGE VARIATION AT RATED FREQUENCY, -5% TO +3% VARIATION IN FREQUENCY AT RATED SUPPLY VOLTAGE, SIMULTANEOUS VARIATION IN VOLTAGE & FREQUENCY THE SUM OF ABSOLUTE PERCENTAGE NOT EXCEEDING 10%.
7. THE MOTOR SHALL BE SUITABLE FOR DIRECT ON LINE STARTING.

$$ **TORQUE SWITCH & LIMIT SWITCH SHALL ACT INDEPENDENT OF EACH OTHER. TANDEM OPERATION IS NOT ACCEPTABLE.**

**EPOXY PAINT IS RECOMMENDED FOR COASTAL AREAS.**

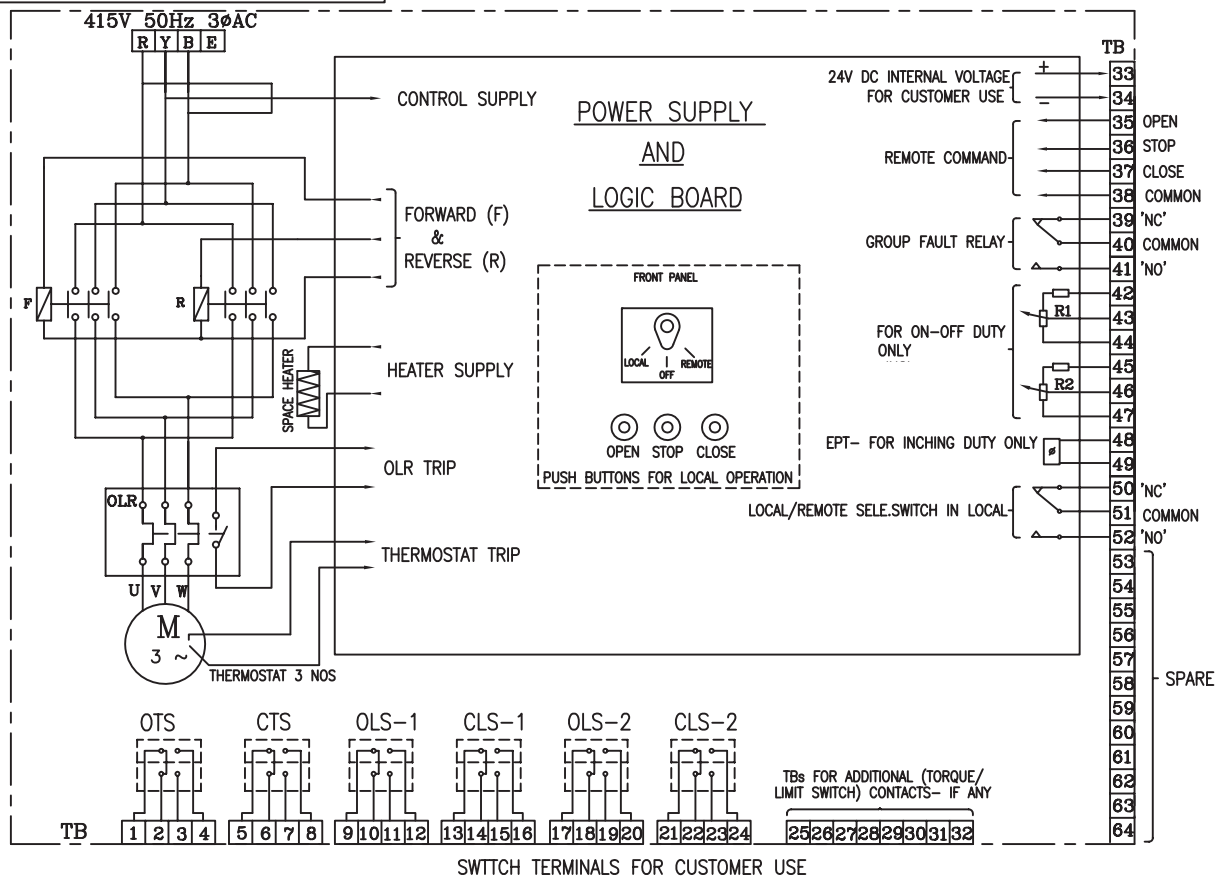
&& INSTRUMENT CABLE SIZE FOR ON/OFF DUTY VALVES SHALL BE 8PXO.5 SQMM - ONE CABLE GLAND OF OD SIZE 20 MM AND FOR INCHING DUTY TYPE VALVES SHALL HAVE TWO NO. CABLES (ONE NO. 8PXO.5 SQMM AND 2ND 2PXO.5 SQMM) - TWO NO. GLANDS OF OD SIZES 20 MM & 15 MM.

	PREPARED BY	CHECKED BY	APPROVED BY	VENDOR COMPANY SEAL
NAME				NAME
SIGNATURE				SIGNATURE
DATE				DATE

NOTES* = TO BE FILLED BY MPL (LEAD AGENCY). @= TO BE FILLED BY ES

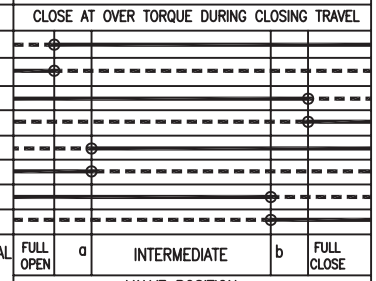
ALL DIMENSIONS ARE IN MILLIMETRES. FOR TOLERANCES OF UNTOLERANCED DIMENSIONS DURING MANUFACTURE REFER RELEVANT QCP / QP.

DRAWING NO. 3-V-MISC-24227



CONTACT DEVELOPMENT DIAGRAM

OTS	1-2	OPEN AT OVER TORQUE DURING OPENING TRAVEL
	3-4	CLOSE AT OVER TORQUE DURING OPENING TRAVEL
CTS	5-6	OPEN AT OVER TORQUE DURING CLOSING TRAVEL
	7-8	CLOSE AT OVER TORQUE DURING CLOSING TRAVEL
OLS-1	9-10	
	11-12	
CLS-1	13-14	
	15-16	
OLS-2	17-18	
	19-20	
CLS-2	21-22	
	23-24	



INDICATES CONTACT CLOSED

INDICATES CONTACT OPEN

CONTACT RATING: 5A AT 250V AC & 0.5A AT 220V DC

INDICATIVE DRAWING

SETTING PROCEDURE OF POSITION LIMIT AND TORQUE SWITCH

VALVES	OPEN		CLOSE	
	MAIN	BACK UP	MAIN	BACK UP
GATE VALVE OF 100 mm AND ABOVE IN 1500 CL AND ABOVE RATINGS	OLS	OTS *	CLS	CTS
ALL OTHER GATE & GLOBE VALVES	OLS	OTS *	CTS	#

– CLS NOT TO BE CONNECTED IN TRIP CIRCUIT

* – BYPASS OTS FOR INITIAL 5% OF TRAVEL (FOR GATE VALVES ONLY)

NOTE:-

1. ALL TORQUE AND LIMIT SWITCHES (OTS,CTS,OLS1&2, CLS1&2) ARE WITH 2NO+2NC CONTACTS '1NO+1NC' IS TERMINATED IN TBS 1-24, REMAINING CONTACTS ARE FOR INTERNAL USE. ANY SPARE CONTACTS WHICH ARE NOT USED INTERNALLY ARE TO BE TERMINATED IN TBS 25-32
2. CTS – TORQUE SWITCHES FOR CW ROTATION (CLOSE)
3. OTS – TORQUE SWITCHES FOR CCW ROTATION (OPEN)
4. OLS-1, OLS-2 – LIMITSWITCHES FOR POSITION OPEN
5. CLS-1, CLS-2 – LIMITSWITCHES FOR POSITION CLOSE
6. EPT – ELECTRONIC POSITION TRAMSMITTER
7. R1-R2-POTENTIOMETER 2 x 100 OHMS
8. FOR COMMANDS & EPT EITHER INTERNALLY GENERATED 24 VDC OR EXTERNAL SUPPLY OF 24VDC CAN BE USED
9. M – MOTOR 3ø 415V 50 Hz AC SUPPLY

REV	DATE	ALTERED
		CHD & APPD

CAUTION: The information on this document is the property of BHARAT HEAVY ELECTRICALS LTD. It must not be used directly or indirectly in any way detrimental to the interest of the company.

TYPE OF PRODUCT OR NAME OF CUSTOMER/PROJECT: ELECTRICAL VALVE ACTUATORS (AC) WITH INTEGRAL STARTERS (DRAWN FOR INTERMEDIATE POSITION OF VALVES)

BHARAT HEAVY ELECTRICALS LTD.,
UNIT: HIGH PRESSURE BOILER PLANT.
TIRUCHIRAPALLI-620014.
365-121

	NAME	SIGN	DATE	NO.OF VAR.
DRN	N.P.ESWAR	N.P	07.10.04	
CHD	D.DINAKARAN	D.D	07.10.04	
APPD	K.ARUNACHALAM	K.A	07.10.04	

DEPT: VL
CODE:
SCALE:
WEIGHT (KG).
REFERENCE INFORMATIONS
NO. OF ITEMS

TITLE: WIRING DIAGRAM (TERMINAL PLAN) FOR ACTUATOR WITH INTEGRAL STARTER

CARD CODE: U 01

DRAWING NO. 3-V-MISC-24227

REV 0

Size A3

SPECIFICATION AND DATA SHEET
FOR
LOCAL CONTROL PANEL

	CONTROL WRITE-UP FOR SUMP PUMPS SYSTEM	DRAWING NO:
	PROJECT: 5X800 MW YADADRI TPS	REV. NO. 00 / DATE:
		SHEET 1 OF 2

CONTROL & INSTRUMENTATION FOR SUMP PUMP SYSTEM

Introduction- Sump pumps are used to dewater various sump pits to nearest surface drain in the power house and other plant areas to ensure general housekeeping.
The system shall normally have 2 pumps. The measuring instruments recommended are level switches (float/displacer type) for level measurement and control of the system and pressure gauges at pump discharge for local pressure measurement. Any other instruments can be included dependent on the requirement or if demanded by the Customer.
The sump pumps can be fixed submersible type where the pumps are fixed and submerged or can be portable submersible type where the pumps are trolley based and can be moved as per the need. In fixed type the level switches can be mounted at a suitable mounting place while in portable type the level switches are ported to the sump along with the pumps. The mounting of switches and location of LCP shall be chosen so as to have minimum cable length between the level switches and the LCP.

CONTROL WRITEUP

The operation of Sump pumps (fixed and portable type) shall be as follows:

Sump Pumps shall be controlled through a starter cum control panel. The local control panel shall be front opening, relay based. The starter cum control panel shall be suitable for indoor or outdoor as per the location of the sump pumps. Normally one pump will be running and the other shall be on auto standby. The following controls/interlocks shall be provided in the local control panel.

Controls philosophy

CONTROLS

(a) Start/stop facility for each pump from LCP.

(b) Selector switch for main/standby selection.

(c) Auto/Manual selector switch for each pump.

AUTO START/STOP

a) One number level switch (high level) provided in the sump shall start one number sump pump in the event of high water level in the sump.

b) One number level switch (very high level) provided in the sump shall start second sump pump in the event of very high water level in the sump.

c) One number level switch (low level) provided in the sump shall stop the running pumps in the event of low water level in the sump.

d) If any of the working sump pumps trips the standby sump pump will come into operation automatically provided the very low level signal is not present.

Indications

a) Sump pumps status (ON/Off/Trip).

b) Level indications(Low,High,V.High)

	CONTROL WRITE-UP FOR SUMP PUMPS SYSTEM	DRAWING NO:
	PROJECT: 5X800 MW YADADRI TPS	REV. NO. 00 / DATE:
		SHEET 2 OF 2

General requirements for measuring instruments

Measuring instruments/equipment and subsystems offered by the Bidder shall be from reputed experience manufacturers (from BHEL/customer approved vendor list) of specified type and range of equipment. Further, all instruments shall be of proven reliability, accuracy, repeatability requiring a minimum of maintenance. All instrumentation equipment and accessories under this specification shall be furnished as per technical specifications, ranges, makes/ numbers as approved by BHEL during detailed engineering.

1. Every panel-mounted instrument, requiring power supply, shall be provided with a pair of easily replaceable glass cartridge fuses of suitable rating. Every instrument shall be provided with a ground terminal and shall be suitably connected to panel grounding bus.
2. The necessary root valves, impulse pipings and all the other accessories required for mounting/erection of local instruments shall be furnished even if not specifically asked for.
3. Instruments shall be terminated up to LCP with control cable (1.5sqmm). The LCP shall be fully wired. All the necessary cables, flexible conduits, junction boxes and accessories for the above purpose shall be included.

`

LOCAL PANEL

1.00.00 **GENERAL REQUIREMENT**

1.01.00 ENCLOSURES FOR INSTRUMENTS AND OTHER EQUIPMENT

1.01.01 All panels, cabinets, distribution boxes, junction boxes, terminal boxes and all other field mounted equipment / enclosures shall have suitable environmental protection as detailed in Section-I of this volume of the specification.

1.02.00 SURFACE PREPARATION & PAINTING

1.02.01 All sheet metal panel/ desk exterior steel surfaces shall be sand blasted, ground smooth and painted as specified below.

1.02.02 Suitable filler shall be applied to all pits, blemishes and voids in the surface. The filler shall be sanded so that surfaces are level and flat; corners are smooth and even. Exposed raw metal edges shall be ground burr-free. The entire surface shall be blast clean to remove rust and scale and all other residue due to the fabrication operation. Oil, grease and salts etc. shall be removed from the panels by one or more solvent cleaning methods prior to blasting.

1.02.03 Two spray coats of inhibitive epoxy primer surfacer shall be applied to all exterior and interior surfaces, each coat of primer surfacer shall be of dry film thickness of 1.5 mil. A minimum of two spray coats of final finish color (Catalyzed epoxy or polyurethane) shall be applied to all surface of dry film thickness 2.0 Mil. The finish colors for exterior and interior surfaces shall conform to the following shades:

- Exterior – Opaline green shade 275 of IS: 5 or equivalent international code..
- Interior - Brilliant White.

1.02.04 Paint films, which show sags, cheeks, blisters, teardrops, fat edges or other painting imperfections, shall not be acceptable.

1.03.00 WIRING

1.03.01 All spare contacts of relays, switches and push buttons shall be wired up to the terminal blocks. All intercommunications between sections of panels/desks shall be furnished.

1.03.02 Each wire shall be identified at both ends with wire designation as per approved wiring diagram. Heat shrinkable type ferrules with indelible computerized ink print shall be used with cross- identification.

1.03.03 All wire termination shall be made with insulated sleeve and crimping type lugs. Wire shall not be spliced or tapped between terminals. Open-ended terminal lugs will not be accepted. Wires shall not be looped around the terminal screws or studs.

1.03.04 Internal wiring should be terminated uniformly on one side of the terminal block leaving the other side available for termination of outgoing cables. Internal wiring shall be grouped so that all outgoing wiring to each particular remote location is terminated on adjacent terminal blocks. Interior wiring and jumperings shall be arranged so that external connections can be made from internal side of terminal blocks. Common connections shall be limited to two (2) wires per terminal.

1.03.05 Wiring shall be arranged to ensure free access to all instrument or devices for maintenance. No wire shall be routed across the face or rear of any device in a manner, which will impede the opening of covers or obstruct access to leads, terminals or devices

1.03.06 Wires shall be dressed and run in trays or troughs with clamp-on type covers. Wirings may be neatly bunched in groups by non-metallic cleats or bands. Each group shall be adequately supported along its run to prevent sagging or strain on termination.

1.03.07 Shield wires shall be terminated on separate terminal blocks. Common connections shall be limited to two wires per terminal. Signal circuit shields shall be grounded at the power supply end only or as recommended by manufacturer.

1.03.08 All low level signal cables shall be separately bundled to from control cable and maintained at 300 mm minimum spacing from control bundles.

1.03.09 Panel internal wiring shall follow distinct color-coding to segregate different voltage levels viz. 24V DC, 48V, 110V AC, 240V AC, 220V DC etc.

1.03.10 Thermocouple lead wires, analyzer measuring lead wires, or any other lead wires carrying measuring signal of the order of low milli volt or micro volt shall be electrically and physically isolated from other AC and DC wiring. Shielded wires used in such cases for panel internal wiring shall be continuous and ungrounded with the shield terminated individually and separately in panel terminal block.

1.03.11 Wiring to door mounted devices shall be provided with multi-strand wires of (49 strands minimum) adequate loop lengths of hinge-wire so that multiple door openings will not cause fatigue failure of the conductor.

1.03.12 Internal wiring in factory pre-wired electronic systems cabinets may be installed according to the Contractor's standard wire size, insulation, and method of termination on internal equipment. Insulation for all wiring, including circuit board wiring, back panel wiring, power supply wiring and interconnecting cables between devices shall pass the vertical flame test per IPCEAS-1981. Identification of conductors may be done by insulation color-coding identified on drawings or by printed wiring lists.

1.04.00 TERMINAL BLOCKS

1.04.01 All terminal blocks shall be rail mounted/ post mounted type, cage clamp type with high quality non-flammable insulating material of melamine suitable for working temperature of 105 Deg C. The terminal blocks in field mounted junction boxes, instrument enclosures racks etc. shall be suitable for cage clamp connections. The terminal blocks in Control Equipment Room termination/ marshalling cubicles shall be suitable for post mounted cage clamp connection at the field input end. The exact type of terminal blocks to be provided by Bidder shall be subject to Owner.

1.04.02 All terminal blocks shall be provided complete with all required accessories including assembly rail, locking pin and section, end brackets, small partitions, transparent covers, support brackets, distance sleeves, warning level, marking etc. For RTDs ring - tong type lugs shall be used at Junction Boxes.

1.04.03 The characteristics of the terminal blocks shall be as follows.

i) High contact force, independent of conductor cross-section and large contact surface area.

ii) Integrated self-loosening protection to avoid shifting of contact surface that may allow contamination of connection point.

iii) Inspection and maintenance free (resistant to thermal aging and vibration)

iv) Low and constant voltage drop

1.04.04 The insulation of the terminal blocks shall be of suitable thermoplastic material.

1.04.05 The spacing between Terminal blocks channels in panels and cubicles shall be adequate for routing the cable troughs and to allow adequate free workspace for termination and removal of wires. The terminal blocks shall be arranged with atleast 100 mm clearance between two sets of terminal blocks and junction box walls.

1.04.06 Signals of different voltage levels shall be clearly segregated by providing separate rows to each type of signal and by using terminal blocks of different color for each type of signal and by providing barrier strips between them.

1.04.07 Terminal blocks shall be provided with white marking strips / self-adhesive marker cards and where permitted by the safety codes and standards, shall be without covers. Power terminals and high voltage (above 48 volts) terminals shall have protection covers. All terminals shall be provided with permanent terminal identification numbers on both sides.

1.04.08 At least 20% spare unused terminals shall be provided on each terminal block for circuit modifications and for termination of all conductors in a multi-conductor control cable.

1.04.09 The bottom of the terminal block shall be at least 200 mm above the cable gland for bottom entry type panels.

1.04.10 For extending 24 V DC supply to panels, the size of the terminals shall be decided based on voltage drop and not based on current.

1.04.11 Other requirements of the terminal blocks are as follows:

i) The last terminal in a rail-mounted assembly shall be closed with an end plate and end bracket.

ii) For visual and electrical separation of terminal groups, partition plates shall be provided, which can be push fitted after forming an assembly.

iii) Design shall permit testing of incoming and outgoing signals by using suitable test plug and socket without disconnecting the cable connections.

iv) It shall be possible to use jumper plugs through the above test plug socket to connect adjacent terminals. Adequate number of short circuit jumper plugs shall be provided for the purpose.

v) Where more than one connection to a terminal block is required, two tier terminals shall be used.

1.05.00 GROUNDING

1.05.01 Separate Protective and Electronic system ground as required shall be provided.

1.05.02 All panels, desks, cabinets shall be provided with a continuous bare copper ground bus (Frame ground), bolted to the panel structure at bottom on both sides and effectively ground the entire structure. The bolts shall face inside of panels.

1.05.03 For electronic system cabinets the electronic system ground bus (Electronic ground) shall be similar but insulated from the cabinet and shall be separately connected to the system ground .The same ground may be used to earth the shield of shielded signal cables, otherwise a separate ground bus shall be provided for connecting the signal cable shields. Cable shields shall be grounded at the panel end only and shall never be left open .The electronic ground between panels of a shipping section shall be firmly looped.

2.00.00 **CONTROL DESKS & PANELS**

2.01.00 GENERAL

2.01.01 All control desk, panels etc. shall be furnished fully wired with necessary provision for convenience outlets, internal lighting, utility receptacles, grounding, ventilation, space heating, anti-vibration pads, internal piping &

accessories as required for completeness of the system.

2.01.02 The design shall conform to the EN ISO 11064 (Ergonomical design of Control Room), Part 1, 2 and 3.

2.01.03 The exact dimensions, material, construction details, grounding, general arrangement etc. shall be as per actual requirement and shall be finalized during detail engineering and subjected to Owner's approval.

2.01.04 Incoming power supply feeders shall be duplicated. Alarm shall be provided for failure of a power supply feed.

2.01.05 For Control desk/ panel mounted instruments/ devices etc. which are to be powered from UPS, all required conversion of interface equipments/ accessories to make such devices compatible with UPS supply shall be provided. All necessary hardware like input switches/ fuse unit for each feeder as well as switch fuse unit for each instrument/ device on the power supply line shall be provided. From UPS redundant feeders shall be provided wih suitably rated MCB and provision of fast auto changeover of UPS feeders.

2.01.06 Crating of the panels and desks shall be suitable for protection against shock, vibration, inappropriate handling and inclement weather conditions during transportation and warehousing. Mounted equipment shall have adequate protection against damage during handling, transit and storage. Suitable desiccant shall be used inside the packing case.

2.01.07 Nameplate

a) Nameplate shall be provided for instrument or device mounted on the panel.

b) Nameplates for panels shall be provided both in front and rear.

2.02.00 CONTROL DESK

2.02.01 Control desk shall be free standing, floor mounting, table top type with doors at back and shall be constructed of 3 mm thick (minimum) CRCA steel or Aluminium extrusion. Aluminium structure shall be anodized or powder coated paint finish. The top surface of control desk shall be 30 mm (minimum) thick with the top 12 mm (minimum) of acrylic solid surface and the remaining 18 mm of laminated medium density fibre (MDF) board.

2.02.02 Monitors with retractable keyboard shall be provided on the desk. Desk shall be arranged in arc-like shape without any sharp edges. Edges shall be extruded PVC or rounded post-formed laminate.

2.02.03 Desks shall be of modular, scalable and industrially ruggedized design and shall have connections for PA system handsets & telephone sets.

2.02.04 Desks shall have concealed cable trays for wire dressing. Both Horizontal & Side Managers (2 separate horizontal cable routing wire baskets for power & data cables) shall be provided.

Each User station will be provided with 2 separate power distribution units (1 for Main line & 1 for UPS line). Each power distribution unit will have 6 points of 5/13 Amp sockets, Mains MCB On/Off Switch & Indicator.

Adequate heat management provision for Exhaust of heat from within the Console Desk Assembly shall be provided. There will be multiple fans provided in the Main Control Desk. Each Fan will be of 230 VAC 250 CFM Ball Bearing based. Ventilation louvers will be provided on both Front & Rear Modesty with special Air Filters. Adequate space for CPU & Other equipments placed with in the desk.

2.02.05 Design shall include Earthing bolts.

2.02.06 Back installed items shall be suitably concealed from front view.

2.02.07 All operator workstations for SG, TG, Auxiliaries & Off-site Plants shall be mounted on this Control Desk. The cabling / wiring between OWS & CPUs, power supply cables etc. shall be aesthetically routed and concealed from view.

2.02.08 HARDWIRED DEVICES ON CONTROL DESK (DRAW OUT SECTION)

Release and Lamp Test push buttons shall be provided for a set of push buttons (decided during detail engineering stage). Depending on the type of control/ function, required number of push buttons/ indicating LEDs & their color, push button stations shall be selected. The size of push button stations shall be 24 x 48 mm or 25 x 50 mm and shall have service inscription details at the front. Emergency push buttons (with cover) shall be mounted on top of Control Desk.

2.03.00 BACK UP PANEL

2.03.01 Construction shall be from CRCA steel of thickness not less than 3mm.

2.03.02 Upright back-up panel shall be provided where hardwired devices shall be mounted on a mosaic grid type console. The mosaic grid tiles shall be of 24 mm x 48 mm (or 25 mm x 50 mm) size, made of heat & flame retardant, self extinguishing and non-hygroscopic material with flat matt finish without glare and non reflecting type.

2.03.03 DDCMIS Back-up Panel (referred as Unit Control Panel-UCP) shall also mount annunciation fascia (minimum 500 nos.) and the flame monitoring cameras along with other hardwired devices as decided during detail engineering stage by Owner. Color coding shall also subject to Owner's approval.

2.03.04 Colored Mimic for different Off-site plant control systems (as enumerated elsewhere in this specification) and hardwired annunciation system shall also

be mounted on the back up panels.

2.04.00 PANELS/CABINETS

2.04.01 All DDCMIS system modules, power supply components and other Local Control panels (PLC/Relay based) shall be housed in cabinets as specified below.

2.04.02 The cabinet mounted equipments shall be fully assembled, installed in mounting racks, wired and fully tested as per specification requirements and Owner approved drawings prior to shipment to the project site.

2.04.03 The Bidder shall ensure that the cabinets are complete & ready for installation before dispatch from manufacturing works. The installation work at project site for these cabinets shall only involve connections through multi-pair cables from marshalling cabinets (wherever provided) to system cabinets and inter-cabinet/cabinet to Control Desk/ Back up Panel.

2.04.04 All electronic cards, network components, power supply modules etc. located shall be suitably housed in cabinets and shall be neatly arranged in sub-racks. Network components shall be visible in door closed condition (e.g. Glass doors etc.) as approved by Owner.

2.04.05 Bidder shall design the cabinet internal arrangement, floor cutout and cable gland plate such that all the cables entering or leaving the cabinet can be properly glanded in the gland plate.

2.04.06 The packaging density of panels shall be such that the temperature rise within the panels shall never exceed 10°C above ambient even under worst operating conditions. Cooling Fans shall be provided wherever required and this shall be of industrial grade.

2.04.07 TECHNICAL PARTICULARS

1.	Material of Construction	:	Cold Rolled Coal Annealed (CRCA) steel sheet	
2.	Thickness of Sheet	:	a)	2.0 mm for faces supporting instruments / terminals
		:	b)	1.6 mm for other sides and top
3.	Construction	:	Welded throughout as per approved National Standards	
4.	Post welding operation	:	a)	Grounding of all welds to smoothness
		:	b)	Rounding of corners

		:	c)	Cleaning of weld spatters
5.	Panel height	:	2300 mm (approx)	
6.	Corners	:	7 mm inner radius	
7.	Dimensional Tolerances	:	a)	In height & length - 3 mm
			b)	In height between adjacent sections - 2 mm
			c)	Total for a group - 6 mm
8.	Doors	:	Double, recessed, turned back edges, full height front & rear	
	i) Thickness of Sheet	:	2 mm	
	ii) Hinges	:	Stainless steel	
	iii) Door latches	:	Three point type	
	iv) Door gaskets	:	Neoprene rubber on fixed frame to result dust proof/weatherproof enclosure	
	v) Opening of the doors	:	Outward	
	vi) Louvers	:	With removable wire mesh to ensure dust and vermin proof	
9.	Gland plates	:	Removable in sections 4 mm thick (bottom)	
10.	Cable entry	:	Bottom	
11.	Hardware	:	a)	Anti vibration pad- 15 mm
			b)	Predrilled base channel ISMC – 100 or equivalent for all sides
			c)	Stainless steel buff- finished 2 mm thick kick plate for all sides
			d)	Stainless steel scratch strips along desk edges fixed with pan-head recessed screws
			e)	Rubber strips to ensure air

tightness between kick plate and finished floor

f) Lifting hook / Eye bolt

g) Drawing pocket

h) Door switch, lamps, thermostat, heaters and industrial grade cooling fans,, illumination fixures

12.	Name Plate	:	Both at front and back surface of the panel
13.	Fixing of name plate	:	Stainless steel pan head screws
14.	Name plate material	:	Laminated phenolic (3 layers)
15.	Lettering	:	Black with white engraved
16.	Mounting of terminal blocks	:	Vertical angle support bracket tack welded on sheet steel plate, screwed on internal wall of enclosure

2.05.00 FURNITURE

All the furnitures in the Central / Local control Room (s), Engineers' rooms, Instrument laboratory , SWAS Room & any other rooms with C&I equipments located in different plant buildings under Bidder's scope shall be included in Bidder's scope of supply. Bidder shall provide following industrial grade furniture items as a minimum from reputed manufacturers/suppliers meeting International Standards. The furniture shall be modular and latest with ease of operational features. The furniture shall be modern, aesthetically designed, modular, flexible, space saving and future safe.

2.05.01 WORK STATION FURNITURE

Modular work station furniture, suitable for mounting servers & historians, programmer stations, PC based systems, printers (A4/A3 color laserjet) etc. shall be provided.

2.05.02 PC RACK

PC Racks shall be provided to mount CPUs of workstations/PCs of OWS/LVS etc. in control room. For each PC / workstation / monitor at least one chair shall be included.

2.05.03 CHAIRS

falling objects and shall be epoxy painted. Canopy shall be of CRCA steel sheet of at least 3 mm thickness.

4.03.02 Rack Major load-bearing posts shall be suitably supported by gusset plates or moment members. Suitable fenders grill shall be welded to the end-posts of the rack to outline a boundary beyond which no mounted equipment shall project to protect instrument from accidental contact during personnel movement. Center posts or any member, which would reduce access, shall be avoided.

4.03.03 2" NB galvanized pipes laid horizontally and supported at two end channels shall be employed at working accessible height for mounting of instruments.

4.03.04 All internal wirings between the instruments and junction box shall run through flexible conduits. No exposed wirings are admissible.

4.03.05 Racks shall have a common blowdown drain header, which will connect individual instrument blowdown line after suitable pressure breaking through regulating globe type blowdown valves. Covered funnels shall be used for saturated liquid and steam service, whereas, open funnels may be used for cold liquid services. Header (2" NB ASTM A 106, Sch-80 Gr. C) shall be suitably sloped and shall have one end flanged and extending beyond the rack for connection to plant drain header..

Each rack shall be provided with one receptacle, one light fixture with wire guard and one lighting switch. Outlet box, switch box and device covers shall be galvanized stamped steel. Light fixtures shall be installed on the canopy of the rack

4.03.06 Power supplies for miscellaneous devices shall be provided with MCB located within the enclosures. MCB shall be mounted in fuse blocks. Nameplates shall be furnished above the MCB blocks, identifying the devices being served.

4.04.00 JUNCTION BOX

1.	Type of Enclosure	:	Dust tight & weatherproof conforming to IP 65
2.	Material	:	3 mm sheet steel / fiberglass reinforced polyester(UV stabilized)
3.	Type of Cover	:	Solid unhinged with retention chain / Screwed at all four corners
4.	Paint	:	i) Exterior : Opaline green shade 275 of IS: 5 ii) Interior - Brilliant Glossy White.

			Surface / Two (2) inch Pipe stanchion
5.	Mounting	:	(At a dry compartment at one side of the enclosure / rack with front opening type door)
6.	Cable Entry	:	3 mm (min) Bottom / side Gland plate
7.	Gasket	:	Neoprene
8.	Grounding	:	Brass earth lug with green screw head External-2 nos , Internal-1no. (M6)
9.	Number of Drain Holes	:	Two at bottom capped
10.	Identification	:	Label for JB and Tags for cable
11.	Accessories	:	a) Rail mounted cage clamp type screwless terminals (suitable for conductor size up to 2.5sq.mm of suitable voltage grade) with markers and 20% spare terminals b) Cable gland (Brass) & raceways c) Ferrules & lugs (Brass) d) Aluminum back panel e) Canopy at top f) Mounting brackets g) bolts and nuts made of brass etc.

SUB-SECTION - IIA

STANDARD TECHNICAL SPECIFICATION (MECHANICAL)

STANDARD TECHNICAL SPECIFICATION FOR COLING TOWER

STANDARD QUALITY PLANS

1.0 GENERAL:

1.1 This standard specification covers the design, manufacture and assembly, inspection and testing at the Vendor's and/or his sub-vendor's works, suitable painting and packing requirements for transportation, erection, commissioning and testing at site of all materials and equipments inclusive of complete electrical and civil works for the Natural Draft Cooling Tower complete with all accessories as specified hereinafter.

2.0 CODES AND STANDARD:

2.1 The design, manufacture, inspection and testing and performance of the Cooling Tower as specified hereinafter shall comply with the requirements of all applicable latest Indian/British/American Standards and Codes of practice. The latest editions of the following standards and publications shall be followed in particular.

a) Cooling Tower Institution of USA, Bulletin ATP-105: Acceptance Test Code for Industrial Water Cooling tower.

b) PTC-23: ASME Performance Test Code for Atmospheric Water Cooling equipment.

c) For Electrical, Civil Codes/ Standards refer respective Specification.

d) BS-4485 – Specification for Water Cooling Tower.

2.2 In case of any conflict between the above codes/ standards and this specification, the later shall prevail and in case any further conflict in the matter, the interpretation of the specification by the Engineer shall be final and binding.

3.0 DESIGN REQUIREMENTS:

3.1 The Cooling Tower shall be designed for continuous operation to cool not less than the design flow of water from specified inlet temperature to outlet temperature at a design ambient wet bulb temperature as indicated under Data Sheet-A enclosed to this specification.

3.2 All the components shall be capable of safe, proper and continuous operation at all cooling water flows up to and including those specified under Data Sheet-A and shall be designed with regard to ease of maintenance, repair, cleaning and inspection.

3.3 The cooling tower shall be Natural Draft cross flow/ counter flow type as per enclosed Data Sheet-A.

3.4 The vendor under this specification shall assume full responsibility in proper design and operation of each and every component of the cooling tower as well as the cooling tower as a whole unit.

3.5 The Cooling tower shall be suitable for handling the fluid as per Data Sheet-A and also for achieving the specified parameters in Data Sheet-A.

3.6 The Cooling tower shall be designed such that the drift losses and the evaporation losses are limited to the values as specified in Data Sheet-A.

3.7 The Cooling Tower structure shall be of adequate strength to withstand the wind load and the effect of earthquake on the structure. Design wind pressure and horizontal/vertical seismic coefficient shall be taken as mentioned in the specification for civil works enclosed to this specification.

4.0 CONSTRUCTIONAL FEATURES:

4.1 Casing and Louver (If required):

4.1.1 The Louvers shall be designed for air entry to the tower with low velocity for minimum pressure drop and less chance of recirculation of moist air. To eliminate splash out, louvers shall slope to shed water inwards.

4.1.2 The louvers and casing shall be made of material as specified in the Data Sheet-A.

4.2 Partitions:

4.2.1 Partitions shall be provided so that one section can be taken out of service without affecting the operation of capacity of other section.

4.3 Fill:

4.3.1 Cooling tower fills type and material shall be as specified in Data Sheet-A.

4.3.2 Design and arrangement of the fills shall be so as to expose high air/ water surface with minimum air pressure drop.

4.4 Fill Supports:

4.4.1 Fills shall be supported at frequent intervals, which shall minimise sag. Possibility of dislodgement and damage to fill materials as a consequence of induced vibration in the fill.

4.5 Drift Eliminations:

4.5.1 Multipass drift eliminators with minimum two-pass zig zag path type shall be provided so as to limit the drift loss to that specified in Data Sheet-A.

4.5.2 The eliminator frame shall be of rugged construction and shall be firmly secured to the structural

frame to arrest vibration. Suitable access to the eliminator frame work from the basin should be provided for any maintenance or physical replacement of eliminator blades etc., when the particular cell is taken out for maintenance.

4.6 **Hot Water Distribution System:**

4.6.1 Motorised/Manual valves (as indicated in Data sheet A) shall be provided in the hot water distribution piping such that each section can be isolated without affecting the operation of other section.

4.6.2 The pipes and valves in hot water distribution system shall be designed to take care of the possible thermal stresses due to temperature variation. This could be achieved by providing sliding supports for supporting all the pipes fabricated from carbon steel.

4.6.3 The hot water distribution piping and valves shall be designed for the design pressure as indicated in the Data Sheet-A.

4.7 **Cold Water Basin:**

4.7.1 The cooling tower basin shall be constructed in RCC (unless otherwise specified in Data Sheet-A). The capacity of the cooling tower basin shall be as indicated in Data Sheet-A.

4.7.2 The cold water basin shall be partitioned into two chambers or as specified in Data Sheet-A. The two sections of the Cooling Tower basin should be separate water tight compartments, which can be isolated one at a time for cleaning/maintenance purposes.

4.7.3 Sludge pits with isolating valves and spool pipe having flanged ends shall be provided for individual basin chamber for connection to drainage pipe.

4.7.4 For each basin chamber, there shall be a cold-water outlet channel. In the connection between basin chamber and cold water outlet channel there shall be a stationary coarse bar screen and gate in the absence of any specific preference under Data Sheet-A.

4.7.5 Each basin chamber shall have an overflow arrangement and scouring arrangement.

4.8 **Submersible sludge Pumps:**

4.8.1 The submersible type sludge pumps complete with electric motors, discharge side valves, piping, supports, hangers and clamps etc. shall be supplied at the option of the purchaser for each cooling tower for basin draining/ desludging. The quantity, design parameters and the materials of construction of the vertical sludge pumps shall be as per Data Sheet-A. Each pump shall be non-clog type, self water lubricated. The vertical sludge pumps shall be treated as an optional item and are to be offered if asked for in the Data Sheet-A enclosed to this specification.

4.9.0 **Screens & Gates in Cold Water outlet Chamber:**

4.9.1 The screens shall be vertical stationary type; the opening size and the mesh aperture shall be as per Data Sheet-A. The guides for the screens to be embedded in the concrete shall be of material as per Data Sheet-A.

Lifting lugs or eye bolts shall be provided on top of the screen frame for ease of handling.

4.9.2 For handling screens, one set of monorail with supporting structure and chain pulley hoist complete with lifting chain and trolley for mounting the hoist shall be furnished. The chain pulley hoist shall be manually operated and shall conform to IS-3832 class-II.

4.9.3 The gates fixed in vertical sections in cold water outlet chamber shall be as per standard practice and quality, material and type shall be as given in Data Sheet-A.

4.9.4 The isolating valves on the scour lines within the sludge pits shall conform to class I of IS-780 and shall be of reputed make.

4.10 **Hardware:**

4.10.1 All nails and fastening bolts, nuts and washers etc used in the cooling tower which are coming in direct contact with water or humid air shall be made of stainless steel 304, all others nuts & bolts etc. shall be made of HDG steel.

4.11.0 **Access:**

4.11.1 Two R.C.C. staircases for approach to the hot water distribution level

4.11.2 Doors for entrance into Cooling Tower Distribution level shall be provided as specified in Data Sheet -A.

4.11.3 Two external ladders for approach to top of cooling tower from water distribution level.

4.11.4 Access/platforms for inspection and maintenance of hot water distribution system along with spray nozzles.

4.11.5 Suitable arrangement for supporting walkways inside the cooling tower shall be made and loading of such arrangement shall be independent of the fill material.

4.11.6 Whether specifically mentioned in the data sheet or not, steel components and fittings used in walkways, handrails and access doors shall be hot dip galvanised after fabrication.

5.0 **INSPECTION AND TESTING:**

5.1 The inspection/ testing of cooling tower and its various components shall be as per the approved Quality Plans.

5.2 Hydrostatic test for the hot water distribution piping shall be conducted at site after complete erection. The test pressure and duration shall be as per Data Sheet-A.

6.0 TEST AT SITE:

6.1 The Cooling Tower as a whole shall be tested at site to check and ascertain that the performance meets the requirements of the specification. It is the responsibility of the vendor to conduct the performance test of the cooling tower and prove the specified parameters to the satisfaction of the purchaser. The test shall be witnessed by the purchaser/ customer's representative or both, for which 15 days clear notice will be given to purchaser by the vendor.

6.2 The performance test of the cooling tower shall be carried out in accordance with cooling tower Institute Bulletin No. ATP 105 Acceptance test for Industrial Cooling Tower.

The details of the proposed test procedure shall be submitted by the vendor sufficiently in advance of the commencement of test for the review and approval of the purchaser.

6.3 Necessary correction curves required for correcting the test results for any difference in test and guaranteed design condition shall be furnished by the supplier for approval along with the proposed test procedure.

6.4 All testing and calibrating instruments required for the site performance test shall be arranged by the cooling tower supplier without any extra cost. All instruments used by the supplier shall be duly calibrated from a recognised Institution and the same is to be arranged by the supplier.

7.0 PERFORMACNE GUARANGTEE, TOLERANCE & PENALTIES:

7.1 Each equipment shall be guaranteed to meet the performance requirement as specified.

7.2 The tests shall be conducted at the manufacturer's works/ site in accordance with this specification and rectification of all defects shall be satisfactory done without charging any extra amount to purchaser.

7.3 The performance test shall be carried out at site as specified and all defects shall be satisfactorily rectified within a time period decided by purchaser. No extra amount shall be charged to purchaser for such rectification. After rectification, retesting will be done by purchaser/ customer's representative without any extra cost to purchaser till satisfactory performance is achieved.

7.4 The vendor shall submit performance curves for the cooling tower showing variation in performance from the design duty point with change in approach to wet bulb temperature,

cooling range, water loading of the tower.

7.5 The vendor shall guarantee the performance of the whole cooling tower plant to meet the specifications when tested in accordance with cooling tower institute acceptance test code ATP-105, performance curves as per ATP-105 shall be furnished by the vendor.

7.6 If any defects are observed, the bidder shall rectify the same without extra cost to the purchaser. Even after rectification if the guaranteed performance is not achieved, then for every increase of 0.5 degree C or part thereof in the cold water temperature over design conditions, a sum as specified in data Sheet-A shall be paid by vendor to the purchaser for shortfall of guarantee, for the cooling tower.

7.6.1 In case the cold water temperature exceeds the acceptable limits of purchaser, the whole plant will be rejected and the vendor shall refund the entire money paid to him together with any penalty levied otherwise.

8.0 SPECIAL CLEANING PROTECTION & PAINTING:

8.1 All equipment shall be neatly finished. All exposed metal/ concrete/ wooden surface shall be smooth and free from burrs/ projections.

The metal surfaces to be painted should be accessible, suitable for priming and affording maximum protection throughout the life of the plant. The surface preparation shall be done either mechanically or chemically by one or more of the methods as given in IS-1477 (Part-I) and shall include the following:

a) Removal of oil, grease, dirt and swarf etc., as per Section 6.1 of IS-1477 (Part-I).

b) Removal of rust and scale etc., as per Section 6.2 of IS-1477 (Part-I).

c) Sand blasting/ shot blasting as per Section 6.2.4 of IS-1477 (Part-I) or wire brushing and picking as specified in Data Sheet-A.

8.2 INSIDE SURFACE OF PIPING & VALVES IN HOT WATER RISERS:

8.2.1 The inside surfaces of the piping and the valves which are in contact with water and which are not made of stainless steel or other corrosion resistant materials shall be painted with coal tar based epoxy paint of approved make and quality over a coat of Zinc Chromate Primer. The thickness of cured coating shall be as specified in Data Sheet-A.

8.3 Outside Surface of Piping (Buried):

8.3.1 Surface treatment as specified in Data Sheet-A.

8.3.2 Coating/ wrapping/ concrete lining as specified in Data Sheet-A.

8.4 **Outside Surface or Piping (Exposed):**

8.4.1 Surface treatment as specified in Data Sheet-A.

8.4.2 One coat of red oxide primer.

8.4.3 Synthetic enamel paint of approved shade, make and quality. The thickness of cured coating shall be as specified in Data Sheet-A.

8.5 All steel parts used for cooling tower construction shall be hot dip galvanised as per IS-4736 after shop fabrication. The external surfaces of the flow regulating valves access platform, access door and also the hoisting derrick subjected to hot water fumes shall also be thoroughly cleaned and treated and shall be coated with rust preventing paints.

8.6 All parts shall be properly boxed, crated or otherwise protected for transportation. Exposed metal finished surfaces shall be thoroughly greased before transportation.

8.7 The external and internal surfaces of the tower shall also be painted.

9.0 **DRAWING AND DATA AFTER AWARD OF CONTRACT:**

The vendor shall furnish drawings and other technical documents as given in Data Sheet-C, enclosed with the specification.

10.0 **SPECIAL TOOLS & TACKLES**:

Special tools & tackles, if any, shall be included in scope of supply by the vendor. A list giving description of such tools & tackles shall be furnished by vendor.

PROJECT

VENDOR

BHARAT HEAVY ELECTRICAL LIMITED
CORPORATE QUALITY ASSURANCE
STANDARD QUALITY PLAN

ITEM : COOLING TOWER

S NO. (01)	COMPONENT /OPERATION (02)	CHARACTERISTICS CHECKED (03)	CATEGOGY (4)	TYPE/METHOD OF CHECK (05)	EXTENT OF CHECK (06)	REFERENCE DOCUMENTS (07)	ACCEPTANCE MORMS (08)	FORMAT OF RECORD (09)	AGENCY (10)			REMARKS (11)
									P	N	V	
1	MATERIAL AND BOUGHT OUT CONTROL											
1.1	FAN BLADE (NON- METALLIC)											
	RESIN	CHEM. PROPS.	MA	CHEM. ANALYSIS	1/BATCH	MFR. SPECH	MFR. SPECH.	MFRS. TC	3		2,1	CORRELATION REQD.
1.2	FAN BLADE (METALLIC)	PHYS.,CHEM. PROPS.	MA	PHYS., CHEM ANALYSIS	1/HEAT	APPD. DATA SHEET	APPD. DATA SHEET	TC	3		2,1	DO
1.3	FAN HUB (CENTRE PORTION, SPOKES,BRACES ETC.)	DO	CR	DO	DO	DO	DO	IR	3/2		2,1	DO
1.4	DRIVE SHAFT & COUPLING	DO	CR	DO	DO	DO	DO	IR	3/2		2,1	DO
1.5	REDUCTION GEAR UNIT- TURN SHAFT,WHEEL, PINION, BEVEL GEARS, CASING	DO	CR	DO	1/CASE	DO	DO	IR	3/2		2,1	DO
	1. SHAFT & GEAR BLADES	SUB- SURFACE DEFECTS	CB	UT	100%	ASTM A388, BACKWALL ECHO 100%	DEFECT ECHO NOT MORE THAN 20% OF BACK WALL ECHO FALL IN BACK WALL ECHOE NOT MORE THAN 20%	IR	3/2	2,1		FOR DIA 50MM AND ABOVE

Q.P.NO.	CQS/SQP/42	SIGNATURE		DATE		DATE			DATE
REV.NO./ DATE	0/1-11-85 ,01 JULY,88	NAME							
PAGE NO.	1 OF 6	PARTY	CUSTOMER/CONSULTANT		BHEL		VENDOR		

PROJECT

VENDOR

BHARAT HEAVY ELECTRICAL LIMITED
CORPORATE QUALITY ASSURANCE
STANDARD QUALITY PLAN

ITEM : COOLING TOWER

S NO. (01)	COMPONENT /OPERATION (02)	CHARACTERISTICS CHECKED	CATEGOGY (4)	TYPE/METHOD OF CHECK (05)	EXTENT OF CHECK (06)	REFERENCE DOCUMENTS	ACCEPTANCE MORMS (08)	FORMAT OF RECORD	AGENCY (10)			REMARKS (11)
									P	N	V	
1.6	HARDWARES	1. PHYS., CHEM. PROPS.	MA	PHYS. ,CHEM.ANALYSIS	IS:2614 TABLE 2	APPD. DATA SHEET	APPD. DATA SHEET	LAB. REPORT	3/2		2,1	
		2. DIMENSIONS, VISUAL DEFECTS	MI	MEAS. ,VISUAL EXAM.	p	MFG. DRG.	MFG. DRG.	LOG BOOK	3/2		2,1	
		3. UNIFORMITY, WT.,ADHESION,SURFACE DEFECTS OF ZINC COATING.	CR	DIP.TEST, STRIP TEST ADHESION TEST, VISUAL EXAM.	IS:5358	IS:5358, APPD DATA SHEET	IS:5358, APPD DATA SHEET	TC	3/2	2,1		
1.7	TIMBER(FOR ALL TIMBER COMPONENTS)											
	1. MATERIAL	1. DEFECTS	MA	VISUAL EXAM.	100%	TECH. SPECN. IS:2372	TECH. SPECN. IS:2372	IR	3/2	2,1		
		2.DIMENSIONS	MA	MEAS.	RANDOM	DO	DO	IR				
	2. PRESERVATIVE TREATMENT	1. PRESERVATIVE RETENTION& PENETRATION	CR	ANALYSIS	1/BATCH	IS:2372,IS:401	IS:2372	IR	3/2	2,1		
1.8	WIRES, WIRE MESH											
	1. WIRES	1. PHYS., CHEM. PROPS	MA	PHYS. ,CHEM. ANALYSIS MEAS.	RANDOM	APPD. DATA SHEET	APPD. DATA SHEET	TC	3/2		2,1	
		2. UNIFORMITY, WT. , ADHESION SURFACE DEFECTS OF ZINC COATING	CR	DIP, STRIP, ADIESION TESTS VISUAL EIAM.	IS:4826	APPD. DATA SHEET IS:4826	APPD. DATA SHEET IS:4826	TC	3/2		2,1	

Q.P.NO.	CQS/SQP/42	SIGNATURE		DATE		DATE			DATE
REV.NO./ DATE	0/1-11-85 ,01 JULY,88	NAME							
PAGE NO.	2 OF 6	PARTY	CUSTOMER/CONSULTANT		BHEL		VENDOR		

PROJECT

VENDOR

BHARAT HEAVY ELECTRICAL LIMITED
CORPORATE QUALITY ASSURANCE
STANDARD QUALITY PLAN

ITEM : COOLING TOWER

S NO. (01)	COMPONENT /OPERATION (02)	CHARACTERISTICS CHECKED	CATEGOGY (4)	TYPE/METHOD OF CHECK (05)	EXTENT OF CHECK (06)	REFERENCE DOCUMENTS	ACCEPTANCE MORMS (08)	FORMAT OF RECORD	AGENCY (10)			REMARKS (11)
									P	N	V	
	2. WIRES - PVC COATING (IF APPLICABLE)	SURFACE DEFECTS, PIN HOLES	CR	VISUAL EXAM. , SPARK TEST	100%	IS:4682 PT.IV	IS:4682 PT.IV	IR	3/2	2,1		
	3. WIRE MESH	MESH, SIZE, SURFACE DEFECTS	MI	MEAS. , VISUAL EXAM.	RANDOM	MFG. DRG.	MFG. DRG.	IR	3/2		2,1	
1.9	NOZZLES,FILLS,FILLS SUPPORT,SPLASH BARS AND OTHER ACCESSORIES	DIMENSIONS, WORKMAMSHIP AND FINISH	MI	DO	RANDOM	MFG. DRG./APPD. DATA SHEET	MFG. DRG./APPD. DATA SHEET	IR	3/2		2,1	
1.10	VIRRATION SWITCH	1. CONTACT RESISTANCE 2. CONTACT RATING 3. INSULATION RES. 4. DI-ELECTRIC STRENTH 5. OPTION	MA	ELEC. TESTS	100%	APPD. DATA SHEET /DRG.	APPD. DATA SHEET /DRG.	IR	3/2	2,1		
		6. DEGREE OF PROTECTION & VIBRATION TEST	MA	ELEC. TESTS	1/TYPE/SIZE	DO-	DO	LAB. REPORT	3/2		2,1	
1.11	PIPES ,FITTINGS & PIPE WORK	REFER STANDARD QUALITY PLAN FOR PIPES, FITTINGS & PIPE WORKS										
1.12	VALVES (ALL TYPES)	REFER RESPECTIVE STANDARD QUALITY PLANS										
1.13	PUMPS	REFER STANDARD QUALITY PLAN FOR CENTRIFUGAL PUMPS.										
1.14	LIGHTING PLAN	REFER STANDARD QUALITY PLAN FOR CONTROL PANELS										

Q.P.NO.	CQS/SQP/42	SIGNATURE		DATE		DATE	DATE
REV.NO./ DATE	0/1-11-85 ,01 JULY,88	NAME					
PAGE NO.	3 OF 6	PARTY	CUSTOMER/CONSULTANT		BHEL		VENDOR

PROJECT

VENDOR

BHARAT HEAVY ELECTRICAL LIMITED
CORPORATE QUALITY ASSURANCE
STANDARD QUALITY PLAN

ITEM : COOLING TOWER

S NO. (01)	COMPONENT /OPERATION (02)	CHARACTERISTICS CHECKED	CATEGOGY (4)	TYPE/METHOD OF CHECK (05)	EXTENT OF CHECK (06)	REFERENCE DOCUMENTS	ACCEPTANCE MORMS (08)	FORMAT OF RECORD	AGENCY (10)			REMARKS (11)
									P	N	V	
1.15	CABLES	1. TYPE TESTS INCLUDING FRLS TESTS	MA	VERF. OF TYPE TEST CERT.	IS:1554	TECH. SPECH. , APPD. DATA SHEET IS:1554, IS:5931	TECH. SPECH. , APPD. DATA SHEET IS:1554, IS:5931	TYPE TC	3		2,1	
		2. ROUTINE TESTS	MA	ELECT. TESTS	DO	DO-IS: 1554	DO-IS: 1554	ROUTINE TC	3		2,1	
		3. ACCEPTANCE TESTS	MA	DO	DO	DO	DO	ACCEPT. TC	3		2,1	
1.16	IN PROCESS CONTROL											
1.17	FAN BLADE(CURED & FORMED)/MACHINED	1. HARDNESS	MA	PHYS. TEST	SAMPLE	APPD. DATA SHEET/MEG.STD. IS:10661	APPD. DATA SHEET/MEG.STD. IS:10661	LOG BOOK/IR	3/2		2,1	11 TO 31 FOR GRP/FRP ONLY.
		2. PROFILE	CR	TEMPLATE/ MEAS.	SAMPLE	MFG. STD./DRG.	MFG. STD./DRG.	IR	3/2		2,1	
		3. DIMENSIONS	MA	MEASUREMENT	SAMPLE	DO	DO	IR	3/2		2,1	
		4.DEFLECTION/PROOF LOAD CAPACITY	CR	DEFLECTION TEST/PROOF LOAD TEST	100%	DO	NO PEMT. DEFCTN./NO CRACK	IR	3/2	2,1		ON METALLIC BLADES ONLY
		5. WORKMANSHIP AND FINISH	MA	VISUAL EXAM.	100%	DO	DO	IR	3/2	2,1		
		6. SURFACE DEFECTS OF HUB ENDS	MA	PT	100%	ASTME 165	NO SURFACE DEFECT	IR	3/2	2,1		
2.2	HUB DRIVE SHAFT & COUPLING (BEFORE GALVANISING)	1. DIMENSIONS	MA	MEASUREMENT	100%	MFG. DRG./STD.	MFG. DRG./STD.	IR	3/2	2,1		
		2. WORKMANSHIP AND FINISH	MA	VISUAL EXAS.	100%	DO	DO	IR	3/2	2,1		
		3. SURFACE DEFECTS	MA	PT	100%	ASTME 165	NO SURFACE DEFECT	IR	3/2	2,1		
		4. STATIC DYNAMIC RESIDUAL UNBALANCE	CR	STATIC DYNANIC BALANCING	100%	ISO 1940	ISO 1940 G 6.3	IR	3/2	2,1		
2.2.1	HUB DRIVE SHAFT & COUPLING (AFTER GALVANISING)	1. UNIFORMITY, WT. ,ADHESION	CR	DIP, STRIP, ADHESION TESTS	1/ BATCH, IS:2633	APPD. DATA SHEET IS:2633	APPD. DATA SHEET IS:2633	IR	3/2	2,1		
		SURFACE DEFECTS OF ZINC COATING		VISUAL EXAM.	100%							

Q.P.NO.	CQS/SQP/42	SIGNATURE			DATE		DATE		DATE
REV.NO./ DATE	0/1-11-85 ,01 JULY,88	NAME							
PAGE NO.	4 OF 6	PARTY	CUSTOMER/CONSULTANT			BHEL		VENDOR	

PROJECT

VENDOR

BHARAT HEAVY ELECTRICAL LIMITED
CORPORATE QUALITY ASSURANCE
STANDARD QUALITY PLAN

ITEM : COOLING TOWER

S NO. (01)	COMPONENT /OPERATION (02)	CHARACTERISTICS CHECKED	CATEGOGY (4)	TYPE/METHOD OF CHECK (05)	EXTENT OF CHECK (06)	REFERENCE DOCUMENTS	ACCEPTANCE MORMS (08)	FORMAT OF RECORD	AGENCY (10)			REMARKS (11)
									P	N	V	
2.3	REDUCTION GEAR UNIT- ALL COMPONENTS	1. WORKMANSHIP AND FINISH,DIMENSIONS	MA	VISUAL EXAM.MEAS.	100%	MFG. DRG.	MFG. DRG.	LOG BOOK /IR	3/2		2,1	
2.3.1	GEARS WORMS	1. HEAT TREATEMENT CYCLE, HARDNESS, CASE DEPTH	MA	VERF OF HT CHART MEAS.	100% RANDOM	MFR. SPECN/APPD. DATA SHEET	MFR. SPECN./APPD. DATA SHEET	HT CHART LOG BOOK	3/2		2,1	
2.3.2	GEARS	1. UNIFORMITY OF CONTACT	MA	BLUE- MATCHING	100%	MFR. SPECN.	MFR. SPECN.	LOG BOOK	3/2		2,1	
2.3.3	SHAFT AND GEARS	1. SURFACE DEFECTS	MA	PT	100%	ASTME 165	NO SURFACE DEFECT	IR	3/2	2,1		
3	ASSEMBLY CONTROL, FINAL TEST											
3.1	FAN ASSEMBLY BLADES WITH HUB	1. STATIC RESIDUAL UNBALANCE	CR	STATIC BALANCING	100%	TECH. SPECN.	NO REDIDUAL UNBALANCE	IR	2	1		
3.2	COMPLETE GEAR BOX	1. GEAR RATIO, ORIENTATION, NOISE,TEMP. RISE, LEAKAGES	MA	VISUAL EXAM. NO LOAD RUNNING FOR ONE HR.	100%	MFG.STD., APPD. DATA SHEET	MFG. STD. APPD. DATA SHEET NO LEAKAGES	IR	3/2	2,1		
3.3	COMPLETE FAN ASSEMBLY	1. AIR DELIVERY 2. POWER CONSUMED 3. FAN EFFICIENCY 4. NIOSE, VIBRATION	CR	PERFORMANCE TEST	1/ TYPE/SIZE	BS 848 PT 1,2 TYPE-C/DULLETIN ATP 105-COOLING TOWER INSTT. OF USA	APPD. DATA SHEET BS 840 PT.1,2 TYPE-C/BULLETIN ATP 105-COOLING TOWER INSTT. OF USA	TYPE TEST REPORT	2		1	IN THE ABSENCE OF TYPE TEST REPORT,TO BE WITNESSED BY BHEL

Q.P.NO.	CQS/SQP/42	SIGNATURE			DATE		DATE					DATE
REV.NO./ DATE	0/1-11-85 ,01 JULY,88	NAME										
PAGE NO.	5 OF 6	PARTY	CUSTOMER/CONSULTANT			BHEL		VENDOR				

PROJECT

VENDOR

BHARAT HEAVY ELECTRICAL LIMITED
CORPORATE QUALITY ASSURANCE
STANDARD QUALITY PLAN

ITEM : COOLING TOWER

S NO. (01)	COMPONENT /OPERATION (02)	CHARACTERISTICS CHECKED	CATEGOGY (4)	TYPE/METHOD OF CHECK (05)	EXTENT OF CHECK (06)	REFERENCE DOCUMENTS	ACCEPTANCE MORMS (08)	FORMAT OF RECORD	AGENCY (10)			REMARKS (11)
									P	N	V	
4.0	COMPLETE COOLING TOWER											
4.1	COMPLETE COOLING TOWER	PERFORMANCE TESTS , DIMENSIONS, WORKMANSHIP & FINISH	CR	PERFORMANCE TEST MEAS.VISUAL EXAM.	100%	TECH. SPECN./APPD. DATA SHEET/DRG.	TECH. SPECN./APPD. DATA SHEET/DRG.	IR	2	1		AT SITE

Q.P.NO.	CQS/SQP/42	SIGNATURE		DATE		DATE			DATE
REV.NO./ DATE	0/1-11-85 ,01 JULY,88	NAME							
PAGE NO.	6 OF 6	PARTY	CUSTOMER/CONSULTANT		BHEL		VENDOR		

MANUFACTURING QUALITY PLAN

NAME OF CONTRACT: STANDARD

NAME OF CONTRACTOR:STANDARD

ITEM /EQUIPMENT : FAN ASSY. QP NO.: PE-QP-999-165-N062

SUB-SYSTEM:COOLING TOWER

DATE : **PAGE 1… OF….4**

SL. NO	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK			REFERENCE DOCUMENT	ACCEPTANCE NORMS		FORMAT OF RECORD	AGENCY			REMARKS
					M	C	N			D		M	C	N	
1.	2.	3.	4.	5.	6.			7.	8.	9.	10.	11.			12.
1	**RAW MATERIAL INSPECTION**														
1.1	Casting For Fan Hub Centre	Chemical Properties	Major	Chemical	1 sample per Heat			Approved drg./ mfg. drg.	Approved drg./ mfg. drg	✓	T.C.	P	V	V	As Cast Heat Mark Required
		Heat Treatment	Do	Heat Treatment	100%	-		Do	Do		HT Chart	P	V	V	
		Mechanical Properties	Do	Mech. test	1 sample per Heat/ HT batch			Do	Do	✓	T.C.	P	V	V	
		Dimensions	Do	Measurement	100%	-		Mfg /Drg.	Mfg. Drg.		IR	P	V	V	
		Surface Defect	Do	Visual	100%	-		Approved drg./ mfg. drg.	Free from Surface Defects		IR	P	V	V	
1.2	Pipes For Spokes & Braces	Review of Mnf. TC for Chemical / Mechanical / Flattening	Major	Review of TC	1 sample per Heat			Approved drg./ mfg. drg.	Approved drg./ mfg. drg	✓	T.C.	P	V	V	
		Dimensions	Do	Measurement	100%	-		Mfg. drg.	Mfg. Drg.		I.R.	P	V	V	
		Surface defect	Do	Visual	100%	-		-	No harmful Defects		Do	P	V	V	
1.3	BLADE CLAMP	Chemical & Mechanical Test	Major	Mech./ Chem.	1 Sample per Heat			Approved drg./ mfg. drg.	Approved drg./ mfg. drg	✓	TC	P	V		
		Appearance	Major	Visual	100 %			Mfg. Drg.	Mfg. Drg.		TC	P	V		
		Dimension	Major	Measurement	Random			Mfg. Drg	Mfg. Drg		TC	P	V		
1.4	HARDWARE	Appearance & Dimension	Major	Visual	Random			Approved Drg./ Mfg. Drg.	Approved Drg./ Mfg. Drg.		IR	P	V		Compliance Report
1.5	GLASS ROVING FIBER GLASS	Weight	Major	Measurement	100 %			Manufacturer ES	Manufacturer's ES		TC	P	V		Manufacturer T.C Shall be submitted for Review.

LEGEND: RECORDS IDENTIFIED WITH 'TICK ' SHALL BE ESSENTIALLY INCLUDED BY CONTRACTOR IN QA DOCUMENTATION

M: MANUFACTURER/SUB-CONTRACTOR
C: MAIN SUPPLIER OF PACKAGE/SYSTEM,
N: BHEL/CUSTOMER/CONSULTANT

P: PERFORM
W: WITNESS
V: VERIFICATION.

	PREPARED BY	REVIEWED BY	APPROVED BY	BHEL	STANDARD
				APPROVED BY	APPROVED BY
	Divyanshu Arora	Maheep Singh	Vishal kumar Yadav		

MANUFACTURING QUALITY PLAN

NAME OF CONTRACT: STANDARD

NAME OF CONTRACTOR:STANDARD

ITEM /EQUIPMENT : FAN ASSY. QP NO.: PE-QP-999-165-N062

SUB-SYSTEM:COOLING TOWER

DATE : **PAGE 2… OF….4**

SL. NO	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK			REFERENCE DOCUMENT	ACCEPTANCE NORMS	D	FORMAT OF RECORD	AGENCY			REMRKS
					M	C	N					M	C	N	
1.	2.	3.	4.	5.	6.			7.	8.		9.	10			11
		Finish & Ribonization	Major	Visual	100 %			--- DO ---	--- DO ---		TC	P	V	-	Manufacturer T.C Shall be submitted for Review.
1.6	POLYSTER RESIN	Physical & Chemical	Major	Review of TC & Visual	Sample			Supplier Test Cerrtificate	Supplier Test Cerrtificate		TC	P	V	-	Manufacturer T.C Shall be submitted for Review.
1.7	FOAM	Free – rise Density	Major	Measurement	Sample			Supplier Test Cerrtificate	Supplier Test Cerrtificate		TC	P	V	-	Manufacturer T.C Shall be submitted for Review.
2	**IN PROCESS INSPECTION**														
2.1	Welding (Hub)	WPS/PQR/WQR	Major	Qualification Verification	100%	-		ASME-IX	ASME-IX		WPS PQR	P	-	-	Refer Note - 1
		NDT on Finished Weld	Critical	DPT	100%	-		ASTM E 165	NO INDICATIONS	✓	IR	P	V	V	
			Critical	RT	10%	-		ASME SEC VIII	ASME SEC VIII	✓	IR	P	V	V	On Butt Weld between Hub & Spokes
		Dimensions	Major	Measurement	100%	-		MFG. DRG.	MFG. DRG.		I.R.	P	V	V	
2.2	FAN BLADE	Appearance	Major	Visual	100 %	10%		Mfg. Drg & Manual K – 1109 P1	Mfg. Drg & Manual – 1109 P1		IR	P	V	V	
		Contour	Major	Measurement	100 %	10%		Mfg. Drg & Manual K – 1109 P1	Mfg. Drg & Manual – 1109 P1		IR	P	V	V	
		Proof Strength/Deflection	Major	Physical Test	100 %	10%		------- DO ----------	------- DO ----------	✓	IR	P	V	V	

LEGEND: RECORDS IDENTIFIED WITH 'TICK ' SHALL BE ESSENTIALLY INCLUDED BY CONTRACTOR IN QA DOCUMENTATION					BHEL	STANDARD
M: MANUFACTURER/SUB-CONTRACTOR **C:** MAIN SUPPLIER OF PACKAGE/SYSTEM, **N**: BHEL/CUSTOMER/CONSULTANT	**P:** PERFORM **W**: WITNESS **V:** VERIFICATION.		PREPARED BY	REVIEWED BY	APPROVED BY	APPROVED BY	APPROVED BY
			Divyanshu Arora	Maheep Singh	Vishal kumar Yadav		

MANUFACTURING QUALITY PLAN

NAME OF CONTRACT: STANDARD

NAME OF CONTRACTOR:STANDARD

ITEM /EQUIPMENT : FAN ASSY. QP NO.: PE-QP-999-165-N062

SUB-SYSTEM:COOLING TOWER

DATE : **PAGE 3… OF….4**

SL. NO	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK			REFERENCE DOCUMENT	ACCEPTANCE NORMS	D	FORMAT OF RECORD	AGENCY			REMRKS
					M	C	N					M	C	N	
1.	2.	3.	4.	5.	6.			7.	8.		9.	10			11.
3	**FINAL INSPECTION**														
3.1	Hot Dip Galvanizing of Fan Hub	Surface Defects	Major	Visual	100%	-		IS:2629	IS:2629	✓	I.R.	P	V	V	HDG Supplier TC' S Shall Be Submitted For Review
		Uniformity Of Coating	Major	Dip Test	Samples as per IS:2633			IS: 2633	IS: 2633	✓	I.R./TC	P	V	V	
		Thickness / Weight / Adhesion of Zn coating	Major	Mechanical	Samples as per IS:4759- 1996			IS:4759 - 1996	Approved drg./ mfg. drg.	✓	Do	P	V	V	
3.2	FAN ASSY. (Hub & Blades)	Overall Dimensions	Major	Visual	100%	20%		Approved drg./ mfg. drg.	Approved drg./ mfg. drg	✓	IR	P	W	W	
		Static Balancing	Do	Measure	100%	20%		Do	Do	✓	Do	P	W	W	CHP
		Blade Track Variations & Tip Clearence.	Do	Measure	100%	20%		Do	Do	✓	Do	P	W	V	
3.3	Identification & Packing	Serial Numbering	Major	Visual	100%			Mfg. Std.	Mfg. Std.	✓		P	V		
		Packing	Do	Visual	100%			Mfg. drg.	Mfg. Drg.	✓		P	V		
3.4	HUB COVER (FRP)	Appearence	Major	Visual	100%			MFG. DRG.	MFG. DRG.	✓	IR	P	V		
		Dimensions	Major	Measurement	100%			MFG. DRG.	MFG. DRG.	✓	Do	P	V		
	Note1:- Only Qualified Welders / WPS shall be used Note2:- Fan Hub will be done at manufacturer's works, Blades & Fan Assy. At manufacturer's works Note 3:-Before sending the documents for approval, supplier to ensure that 'Reference documents' and 'Acceptance norms" do contain data required for the characteristics to be checked as indicated in QP.														

LEGEND: RECORDS IDENTIFIED WITH 'TICK ' SHALL BE ESSENTIALLY INCLUDED BY CONTRACTOR IN QA DOCUMENTATION

M: MANUFACTURER/SUB-CONTRACTOR
C: MAIN SUPPLIER OF PACKAGE/SYSTEM,
N: BHEL/CUSTOMER/CONSULTANT

P: PERFORM
W: WITNESS
V: VERIFICATION.

	PREPARED BY	REVIEWED BY	APPROVED BY	BHEL	STANDARD
	Divyanshu Arora	Maheep Singh	Vishal kumar Yadav	APPROVED BY	APPROVED BY

	MANUFACTURING QUALITY PLAN **NAME OF CONTRACT: STANDARD** **NAME OF CONTRACTOR:STANDARD**	**ITEM /EQUIPMENT : FAN ASSY. QP NO.: PE-QP-999-165-N062** **SUB-SYSTEM:COOLING TOWER** **DATE :** **PAGE 4… OF….4**

LEGEND: RECORDS IDENTIFIED WITH 'TICK ' SHALL BE ESSENTIALLY INCLUDED BY CONTRACTOR IN QA DOCUMENTATION						BHEL	STANDARD
M: MANUFACTURER/SUB-CONTRACTOR **C:** MAIN SUPPLIER OF PACKAGE/SYSTEM, **N**: BHEL/CUSTOMER/CONSULTANT	**P:** PERFORM **W**: WITNESS **V:** VERIFICATION.		PREPARED BY	REVIEWED BY	APPROVED BY	APPROVED BY	APPROVED BY
			Divyanshu Arora	Maheep Singh	Vishal kumar Yadav		

	QUALITY PLAN	CUSTOMER:	PROJECT:		SPEC. NO :
		BIDDER/VENDOR	QP NO.PE-QP-999-100-M004	REV. 00 DT.31.03.99	SPEC. TITLE
	SHEET 1 OF 3	SYSTEM **POWER CYCLE/ LP VALVES**	ITEM: GATE/ GLOBE VALVE		SECTION VOLUME

S.NO.	COMPONENT/ OPERATION	CHARACTERISTICS CHECKED	CATE-GORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
1.0	**MATERIALS**											
1.1	BODY,BONNET, YOKE,WEDGE/DISC, SPINDLE, BODY SEAT, BACK SEAT, THRUST PLATE	1. PHYS,CHEM,PROPS	MA	PHYS,CHEM. TESTS	ONE/HEAT	APPD. DRG./ TECH.SPEC.	APPD. DRG./ TECH.SPEC.	TEST CERT.	3/2	2	1	CORRELATION REQD. FOR BODY BONNET, SPINDLE - FOR GREY C.I. ONLY PHYS. TEST.
		2. HEAT TREATMENT	MA	REVIEW OF H.T. CHART	100%	-DO-	-DO-	H.T. CHART	3/2	2	1	
		3. SURFACE DEFECTS	MA	VISUAL	100%	MSS-SP-55	MSS-SP-55	INSPN. REPORT	3/2	2	1	
1.2	BODY & BONNET FOR RATING 900 & ABOVE (ALSO FOR LOWER RATING IF REQUIRED IN SPEC.)	1. SURFACE DEFECTS	CR	PT/MT	100%	ANSI B16.34 AND TECH. SPEC.	ANSI B16.34 AND TECH. SPEC.	-DO-	3/2	2,1	-	
		2. SUB-SURFACE DEFECTS	CR	RT/UT	100%	ANSI B16.34 AND TECH. SPEC.	ANSI B16.34 AND TECH. SPEC.	-DO-	3/2	-	2,1	FILM REVIEW BY BHEL
1.3	ACTUATORS 1. ELECTRIC ACTUATORS	1. TORQUE TESTING & SETTING OF TORQUE SWITCH	MA	MECH., ELEC. TESTS	100%	TECH. SPEC./ APPD. DRG./ DATA SHEET/ IS:9334	APPD. DRG./ DATA SHEET./ IS:9334	INSPN. REPORT	3	2,1	1 *	*BHEL TO WITNESS IF QTY. MORE THAN 10/ TYPE
		2. TRAVEL/STROKE	MA									
		3. TRAVEL TIME	MA									
		4. OPERATION OF LIMIT SWITCH	MA									
		5. MANUAL OPERATION THROUGH HAND WHEEL	MA									
		6. OPERATION TEST WITH POWER SUPPLY VARIATION ENERGISES TO OPEN/CLOSE	MA									
		7. IR,HV,IR	MA									
		8.DEGREE OF PROTECTION	MA	WATER, DUST TEST	1/TYPE	TECH. SPEC./ APPD. DRG./ DATA SHEET/ IS:9334	APPD. DRG./ DATA SHEET/ IS:9334	3RD PARTY TEST CERT.	3	-	2,1	

BHEL	PARTICULARS	BIDDER/VENDOR	
	NAME		
	SIGNATURE		
	DATE		BIDDER'S/ VENDOR'S COMPANY SEAL

	QUALITY PLAN	CUSTOMER:	PROJECT:		SPEC. NO :
		BIDDER/VENDOR	QP NO.PE-QP-999-100-M004	REV. 00 DT.31.03.99	SPEC. TITLE
	SHEET 2 OF 3	SYSTEM **POWER CYCLE/ LP VALVES**	ITEM: GATE/ GLOBE VALVE		SECTION VOLUME

S.NO.	COMPONENT/ OPERATION	CHARACTERISTICS CHECKED	CATE-GORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
	2. PNEUMATIC ACTUATORS	1. LEAK TIGHTNESS	CR	PNEUMATIC TEST AT 1.2 X DESIGN	100%	APPD. DATA SHEET/MFG. STD.	NO LEAKAGE	INSPN. REPORT	3	2,1	1*	*BHEL TO WITNESS IF QTY. MORE THAN 10/ TYPE
		2. ACCURACY	CR	CALIBRATION	100%	-DO-	APPD. DATA SHEET/MFG. STD.	CALIBRATION REPORT	3	2,1	1*	
		3. SIMULATION (OPERATION, AIR TO OPEN/CLOSE)	CR	OPERATION AT RATED PRESSURE	100%	-DO-	-DO-	INSPN. REPORT	3	2,1	1*	
2.0	SS/STELLITE DEPOSIT ON DISC / BODY SEAT/BACK SEAT	1. SURFACE DEFECTS	CR	P.T	100%	ASTME:165 & TECH.SPEC.	ANSI B16.34 & TECH.SPEC.	-DO-	3/2	2,1	2,1	FOR 900 CLASS & ABOVE TO BE WITNESSED BY BHEL
3.O	IN-PROCESS INSPECTION											
3.1	MACHINING OF ALL COMPONENTS	1. DIMENSIONS, WORKMANSHIP AND FINISH	MA	MEAS.,VISUAL	100%	MFG.DRG.	MFG.DRG.	LOG BOOK	3/2	-	-	
3.2	WEDGE/DISC, BODY SEAT RING, BACK SEAT, SPINDLE, THRUST PLATE	1. HARDNESS	MA	TESTING	100%	APP.DRG.	APP. DRG./ ANSI B16.34	TEST CERT.	3/2	-	2,1	
3.3	SPINDLE, BODY SEAT RING, WEDGE/DISC, BACK SEAT	1. SURFACE DEFECTS	CR	P.T.	100%	ANSI B16.34 AND TECH. SPEC./	ANSI B16.34 AND TECH. SPEC.	-DO-	3/2	-	2,1	
3.4	WEDGE/DISC & SEAT RING, SPINDLE AND BACK SEAT	1. LAPPING	CR	BLUE MATCHING	100%	UNIFORM METAL TO METAL CONTACT		INSPN. REPORT	3/2	-	2,1	
4.0	ASSEMBLY	1. DIMENSIONS	MA	MEAS.	100%	APPD.DRG.	APPD.DRG.	-DO-	3/2	2,1	-	
		2. WEAR TRAVEL	MA	MEAS.	100%	-DO-	-DO-	-DO-	3/2	2,1	-	FOR GATE VALVES ONLY
		3. VALVE LIFT	MA	MEAS.	100%	-DO-	-DO-	-DO-	3/2	2,1	-	
5.0	TESTING											
5.1	BODY, SEAT, BACK SEAT	1. LEAK TIGHTNESS OF BODY	CR	HYDRAULIC TEST	100%	APPD. DRG./ TECH. SPEC.	NO LEAKAGE	I.R./ IBRTC (IF REQD)	3/2	2,1	-	
		2. LEAK TIGHTNESS OF BACK SEAT AND SEAT	CR	-DO-	100%	-DO	-DO-	-DO-	3/2	2.1	-	
		3. LEAK TIGHTNESS OF SEAT	CR	PNEUMATIC TEST	100%	-DO	-DO-	-DO-	3/2	2.1	-	

BHEL	PARTICULARS	BIDDER/VENDOR	
	NAME		
	SIGNATURE		
	DATE		BIDDER'S/ VENDOR'S COMPANY SEAL

	QUALITY PLAN	CUSTOMER:	PROJECT:		SPEC. NO :
		BIDDER/VENDOR	QP NO.PE-QP-999-100-M004	REV. 00 DT.31.03.99	SPEC. TITLE
	SHEET 3 OF 3	SYSTEM **POWER CYCLE/ LP VALVES**	ITEM: GATE/ GLOBE VALVE		SECTION VOLUME

S.NO.	COMPONENT/ OPERATION	CHARACTERISTICS CHECKED	CATE-GORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
5.2	SEAT & BACK SEAT FOR MOTORISED/ PNEU. VALVES WITH ACTUATOR	1. LEAK TIGHTNESS OF SEAT	CR	HYDRUALIC TEST	100%	APPD. DRG./ TECH. SPEC.	NO LEAKAGE	I.R./ IBRTC (IF REQD)	3/2	2.1	-	
5.3	OPERATION AL TESTING											
	1. MANUALLY OPERATED VALVES	1. SMOOTH & FULL OPENING AND CLOSING	CR	MANUAL	100%	TECH. SPEC.	SMOOTH OPERATION OF VALVES & CLEAR BORE	INSPN. REPORT	3/2	2,1	-	
	2.MOTOR /PNEU OPERATED VALVES	1. ASCENDING& DESCENDING LIFT CHARACTERISTIC	CR	ELEC.	100%	APP. DRG./ TECH. SPEC./ IS:9334	APP. DRG./ TECH. SPEC./ IS:9334	INSPN. REPORT	3/2	2,1	-	
		2. LIMIT/TORQUE SWITCH SETTING FOR OPENING AND CLOSING TIME	CR	ELEC.	100%	APP. DRG./ TECH. SPEC./ IS:9334	TECH. SPEC./ APPD.DRG	INSP. REPORT	3/2	2,1	-	
6.0	COMPLETE VALVES	1. OVERALL DIMENSION	MA	MEAS	SAMPLE	APPD.DRG	APP.DRG.	-DO-	3/2	2,1	-	
7.0	END CONNECTION DETAILS	1. DIMENSIONS	MA	MEAS.	100%	APPD. DRG. / RELV.STD	APPD. DRG. / RELV.STD	-DO-	3/2	2,1	-	
		2. SURFACE DEFECTS FOR B.W. ENDS	CR	PT	100%	ASTME:165	NO DEFECTS	TEST CERT.	3/2	2	1	
8.0	FINAL INSPECTION	1. CLEANLINESS & COMPLETENESS	MA	VISUAL	100%	APPD. DRG./ TECH. SPEC.	APPD. DRG./ TECH. SPEC	INSPN. REPORT	3/2	-	2,1	
9.0	PAINTING	1. SURFACE PREPARATION	MI	VISUAL	100%	TECH. SPEC.	TECH. SPEC.	INSPN. REPORT	3/2	-	2,1	
		2. UNIFORMITY & THICKNESS	MI	MEASUREMENT	100%	-DO-	-DO-	-DO-	3/2	2	1	
10.0	PACKING	AS PER BHEL TECH. SPEC	MA	VISUAL	100%	AS PER BHEL TECH. SPEC.	AS PER BHEL TECH. SPEC	-DO-	3/2	-	2,1	

ABBREVIATIONS

CR = CRITICAL CHARACTERISTIC **P = PERFORMED BY** **W = WITNESSED BY** **V = VERIFIED BY**
MA =MAJOR CHARACTERISTIC **1 = PURCHASER (BHEL)** **2 = VENDOR** **3 = SUB VENDOR OF THE VENDOR**
MI = MINOR CHARACTERISTIC

BHEL	PARTICULARS	BIDDER/VENDOR	
	NAME		
	SIGNATURE		
	DATE		BIDDER'S/ VENDOR'S COMPANY SEAL

QUALITY PLAN SHEET 1 OF 3	CUSTOMER :	PROJECT :		SPEC. NO
	BIDDER/VENDOR	QP NO.PE-QP-999-100-MO41	REV.00 DT. 31.03.99	VOLUME: II-B
	SYSTEM:	ITEM: PIPES & FITTINGS		SECTION D

S.NO.	COMPONENT/ OPERATION	CHARACTERISTICS CHECKED	CATE GORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
1.0.0	MATERIAL CONTROL											
1.1.0	PIPES (MILL MADE)	1. PHY., CHEM. PROPS, DIMENSIONS, SURFACE FINISH, HEAT TREATMENT (IF APPLICABLE), LEAK TIGHTNESS	MA	PHY, CHEM . TESTS MEASUREMENTS, VISUAL EXAM, VERI. OF HT CHART HYDRO TEST	TECH. SPEC., IS:4711	APPD. DATA SHEET/ TECH. SPEC.	APPD. DATA SHEET/ TECH. SPEC.	MFR.TC/ LAB REPORT	3	-	2,1	SAMPLE IDENTIFICATION BY BHEL
1.2.0	FITTINGS	1. PHY, CHEM. PROP.,	MA	PHY., CHEM. TESTS	1/HEAT	-DO-	-DO-	-DO-	3/2	-	2,1	-DO-
		2. DIMNS., SURFACE FINISH, HEAT TREATMENT (IF APPLICABLE)	MA	MEASUREMENTS, VISUAL EXAM, VERI. OF HT CHART	100%	-DO-	-DO-	-DO-	3/2	-	2,1	
1.3.0	PLATE FOR FLANGES, FABRICATED PIPING AND FORGINGS FOR FLANGES	1. PHY. CHEM. PROP.,	MA	PHY., CHEM. TESTS	1/CAST	-DO-	-DO-	-DO-	3	-	2,1	-DO-
		2. DIMNS., SURFACE FINISH, HEAT TREATMENT (IF APPLICABLE)	MA	MEASUREMENTS, VISUAL EXAM VERI. OF HT CHART	100%	-DO-	-DO-	-DO-	3	-	2,1	
2.0.0	IN PROCESS CONTROL											
2.1.0	PIPES, FITTINGS, FLANGES - MACHINING, BENDING	1. DIMNS. INCLUDING THINNING, OVALITY, FINISH, WRINKLES ETC.	MA	MEASUREMENTS, VISUAL EXAM.	100%	MANUFAC-TURING DRG.	MANUFAC-TURING DRG.	I. R	3/2	-	2,1	
2.2.0	WELDING PROCEDURE SPECIFICATION	1. CORRECTNESS	MA	EXAM	100%	IS:7307/ ASME - IX	IS:7307/ ASME - IX	FORMAT OF IS:7307/ ASME - IX	3/2	-	2,1	
2.3.0	PROCEDURE QUALIFICATION AND WELDER'S QUALIFICATION	1. WELD SOUNDNESS	MA	PHY. TESTS	ASME IX IS:7310 IS:7307	IS:7310/ ASME - IX	IS:7310/ ASME - IX	FORMAT OF IS:7310/ ASME - IX	3/2	2,1	-	
2.4.0	WELD FIT-UPS	1. DIMNS.,	MA	MEASUREMENT,	100 %	W.P.S,	W.P.S,	I.R	3/2	2	1	

BHEL	PARTICULARS	BIDDER/VENDOR	
	NAME		
	SIGNATURE		
	DATE		BIDDER'S/ VENDOR'S COMPANY SEAL

	QUALITY PLAN SHEET 2 OF 3	CUSTOMER :		PROJECT :			SPEC. NO					
		BIDDER/VENDOR		QP NO.PE-QP-999-100-MO41 REV.00 DT. 31.03.99			VOLUME: II-B					
		SYSTEM:		ITEM: PIPES & FITTINGS			SECTION D					

S.NO.	COMPONENT/ OPERATION	CHARACTERISTICS CHECKED	CATE GORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
		ALIGNMENT, ORIENTATION		VISUAL		APPD. DRGS.	APPD. DRGS.					
2.5.0	**WELDS**											
	A) BUTT WELDS WITH JOINT EFFICIENCY OF 1.0 & 0.9											
	I) ROOT RUN	I) WELD DEFECTS	MA	PENETRANT TEST	100%	IS:3658/ ASTM E 165	ASME VIII DIV.I ASME B 31.1	INSPN. REPORT	3/2	2	1	
	ii) FINAL RUN	I) WELD DEFECTS	MA	-DO-	100%	-DO-	-DO-	-DO-	3/2	2/1	-	
				RADIOGRAPHY TEST	100% FOR JT. EFF. 1.0 & 10% FOR JT. EFF. 0.9	ASME B 31.1	ASME B 31.1	-DO-	3/2	-	2/1	FILMS TO BE SHOWN TO BHEL FOR APPROVAL
	B) OTHER BUTT WELDS WITH JOINT EFF. LESS THAN 0.9	1. WELD DEFECTS (FOR ROOT RUN & FINAL RUN)	MA	PENETRANT TEST	100%	IS:3658/ ASTM E 165	ASME B 31.1	INSPN. REPORT	3/2	2,1	-	
3.0.0	COMPLETE PIPE WORK & PIPES INCLUDING GALVANIZED/ RUBBER LINED PIPING (BEFORE GALVANIZING/ RUBBER LINING)	1. WORKMANSHIP AND FINISH, DIMNS., ORIENTATION, LEAK TIGHTNESS	CR	MEAS, VISUAL, HYDRO TEST AT 1.5 X DESIGN PRESS.	100%	APPD. DRGS.	APPD. DRGS., NO LEAKAGE	I.R.	3/2	2,1	-	
3.1.0	COMPLETE PIPE WORK (DULY GALVANIZED AS APPLICABLE)	1. FREEDOM FROM SURFACE DEFECTS	MA	VISUAL	100%	IS:4736/ IS 2629 & TECH. SPECN.	IS:4736/ IS 2629 & TECH. SPECN.	INSPN. REPORT	3/2	2,1	-	
		2. UNIFORMITY OF COATING	MA	DIP TEST	SAMPLING AS PER IS	IS 2633 & TECH. SPECN.	IS 2633 & TECH. SPECN.	-DO-	3/2	2,1	-	

BHEL	PARTICULARS	BIDDER/VENDOR	
	NAME		
	SIGNATURE		
	DATE		BIDDER'S/ VENDOR'S COMPANY SEAL

QUALITY PLAN SHEET 3 OF 3	CUSTOMER :	PROJECT :		SPEC. NO
	BIDDER/VENDOR	QP NO.PE-QP-999-100-MO41	REV.00 DT. 31.03.99	VOLUME: II-B
	SYSTEM:	ITEM: PIPES & FITTINGS		SECTION D

S.NO.	COMPONENT/ OPERATION	CHARACTERISTICS CHECKED	CATE GORY	TYPE/METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
		3. MASS OF ZINC COATING	MA	STRIP TEST	-DO-	IS 4736/ IS 6745 & TECH. SPECN.	IS 4736 & TECH. SPECN.	-DO-	3/2	2,1	-	
		5. ADHESION	MA	ADHESION TEST	-DO-	IS-2629/ IS 4736 & TECH. SPECN.	IS-2629/ IS 4736 & TECH. SPECN.	-DO-	3/2	2,1	-	
3.2.0	COMPLETE PIPE WORK (RUBBER LINING AS APPLICABLE)	---------- AS PER QUALITY PLAN FOR RUBBER LINING----------										
4.0.0	PAINTING AND PACKING	1. SURFACE PREPARATION, DFT, NO. OF COATS, SOUNDNESS OF PACKING, MARKING ETC.	MA	VISUAL EXAM, MEASUREMENT	100%	APPD. PROCEDURE	APPD. PROCEDURE	I.R, MFRS CHECK LIST	3/2	-	2,1	

BHEL	PARTICULARS	BIDDER/VENDOR	
	NAME		
	SIGNATURE		
	DATE		BIDDER'S/ VENDOR'S COMPANY SEAL

BHARAT HEAVY ELECTRICALS LIMITED

MANUFACTURERS NAME & ADD

MANUFACTURING QUALITY PLAN

ITEM : Sump pumps/Submersible Pump

QP NO: PE-QP-999-100-N005
REV-02
DATE: 14.06.16
PAGE 1 OF 2

PROJECT :
END CUSTOMER:
CONTRACT No.:
MAIN SUPPLIER: BHEL, Noida

SR. NO	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	D*	AGENCY M	AGENCY B	AGENCY C	REMARKS
1	2	3	4	5	6	7	8	9	D*	10			
1.0	**Raw Material and Bought out Control**												
1.1a	Pump Casing	Physical Properties - Tensile Strength & Hardness / Chemical Composition	CR	Physical / Chemical Analysis	1 / Heat / Batch	Appd. C S Drg.	Approved drawing/Data sheet	Lab Report	√	P	V	V	
1.1b	Impeller	Physical Properties - Tensile Strength, Yield Strength & Elongation Chemical Composition	CR	Physical / Chemical Analysis	1 / Heat / Batch	Appd. C S Drg.	Approved drawing/Data sheet	Lab Report	√	P	V	V	
1.2	Heat treatment of Stainless Steel Castings	Heat Cycle	MA	Verification of HT chart	All Batches	Appd. C S Drg.	Approved drawing/Data sheet	Corelated HT charts	√	P	V	V	
1.3	Bars / forgings for pump and motor shafts	Physical/Chemical Properties	CR	Physical / Chemical Analysis	1 / Bar	Appd. C S Drg.	Approved drawing/Data sheet	Mill TC or lab report	√	P	V	V	
		Dimensions	MA	Measurment	100%	Manufacturers Drawing	Manufacturers Drawing	IR		P	V	V	
		Internal defects for 40 mm and above diameter	CR	UT	100%	ASTM A-388	Refer Note 1	IR	√	P	V	V	
1.4	Cable Type: PVC insulated, multicore, copper conductor	Routine TC and acceptance TC as per IS 694/Is1554, Length and size	MA	Measurement	100%	Approved Datasheet / IS 694/IS1554	Approved Datasheet / IS 694/IS1555	IR & TC	√	P	V	V	Compliance cert. To be submitted by Vendor
1.5	Bearings	Make, Bearing No., Surface finish	MA	Visual Examination	100%	Manufacturers Std	Manufacturers Std	IR		P	V		
2.0	**Inprocess Control**												
2.1	All Components	Visual Defects	MA	Visual	100%	Manufacturers Drawing	No harmful defects	Log book / IR		P	V	V	
		Dimensions	MA	Measurement	100%	Manufacturers Drawing	Manufacturers Drawing	Log book / IR		P	V	V	
2.2	Pump discharge casing	Leak tightness	CR	Hydro test (Duration 30 minutes min.)	100%	Refer Remark.	No leakage	IR	√	P	W	V	Test Pr.2 x duty pts. Pr. OR 1.5 x shut off whichever is higher
	Motor Housing	Leak tightness	CR	Air test (Duration 30 Minutes min)	100%	Air test at 0.5 kg/cm2 (guage pressure)	No leakage	IR	√	P	V	V	
2.3	Casing & Impeller (machined surfaces)	Surface Defects	CR	DPT	100%	ASTME:165	No Surface defect	IR	√	P	V	V	On machined surface only
2.4	Impeller	Static & Dynamic residual unbalance	CR	Static, Dynamic balancing	100%	ISO : 1940	ISO 1940 Gr. 6.3	IR	√	P	V	V	
2.5	Pump Motor Shaft	Internal Defects	CR	DPT	100%	ASTME:388	ASTME:388, Refer note 1	IR	√	P	V	V	On machined surface only
		Surface Defects	CR	DPT	100%	ASTME:165	No Surface defect	IR	√	P	V	V	On machined surface only
3.0	**Sub-Assembly, Assembly Control**												
3.1	Pump, Motor, Rotor	Eccentricity	MA	Measurement	100%	Manufacturers Drawing	Manufacturers Drawing	Log book / IR		P	V	V	
3.2	Pump and Motor assembly	Completeness, correctness	MA	Visual Examination	100%	Manufacturers Drawing	Manufacturers Drawing	IR		P	V	V	

LEGEND: RECORDS IDENTIFIED WITH "TICK" ( ) SHALL BE ESSENTIALLY INCLUDED BY SUPPLIER IN QA DOCUMENTATION

** **M:** MANUFACTURER/SUB CONTRACTOR
B: BHEL, **C**:CUSTOMER (END USER)
P : PERFORM **W:** WITNESS **V :** VERIFICATION AS APPROPRIATE

BHEL DOC No.:PE : V8 - XXX - 100-N005

NAME AND SIGN OF APPROVING AUTHORITY AND SEAL

MANUFACTURER/ SUBCONTRACTOR — BHEL CONTRACTOR

SIGNATURE

ENGG DIV / QA & I

	BHARAT HEAVY ELECTRICALS LIMITED	MANUFACTURERS NAME & ADD		MANUFACTURING QUALITY PLAN									
				ITEM :	Sump Pump/Submersible Pump		QP NO: PE-QP-999-100-N005			PROJECT :			
							REV-02			END CUSTOMER:			
							DATE: 14.06.16			CONTRACT No.:			
							PAGE 2 OF 2			MAIN SUPPLIER:			BHEL, Noida

SR. NO	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	D*	AGENCY M	AGENCY B	AGENCY C	REMARKS
1	2	3	4	5	6	7	8	9	D*	10			
4.0	**Final Inspection, Test, Packing, Despatch Control**												
4.1	Pump set (Pump+ Motor)	Q Vs Head, Q Vs Power Q Vs Efficiency	CR	Performance test	100%	Tech. Spec., Appd. Data Sheet, Appd. Curves, HIS, Test procedure	Tech. Spec., Appd. Data Sheet, Appd. Curves, HIS	Performance test record, Plotted Curves	Ö	P	W	V	
4.2	Routine Test on motor	HV, IR, Locked Rotor, No Load, Make type, Rating	CR	Electrical tests	100%	IS 325	Approved Data Sheet	IR	Ö	P	V	V	Widing resistance ** Degree of protection shall be IP 68, HV at 2.5 KV AC for 1 Minute.
4.3	Strip down after Performance test	Undue wer, tear and breakages	CR	Visual examination of Casing & Impeller after stripping	100%	Undue wer, tear and breakages	No undue wear, tear and breakages	IR	Ö	P	W	V	Witnessing one no. of each type
4.4	Complete Pump	Completeness, Correctness, Workmanship and finish, overall dimensions	MA	Visual examination	100%	Approved G.A. drawing	Approved G.A. drawing	IR	Ö	P	V	V	Compliance report for accessories will be submitted.
4.5	Completion of all stages	Completion	MA	Verification of IR's TC's	100%	Approved QP	Approved QP	IR	Ö	P	V	V	
4.6	Painting	Surface Preparation		Visual examination	100%	Approved data sheet/Manufacurer standard		IR		P	V	V	Compliance report by Manufacurer
		Adhesion, Uniformity and thickness		Visual Measurement	100%	As per painting schedule/Manufacurer standard		IR		P	W	V	Compliance report by Manufacurer
4.7	Wooden Packing	Soundness, Aesthetic		Visual	100%	As per packing procedure		IR		P			Compliance report by Manufacurer

Note :

1. For accessories and bought out items, Manufacurer will submit Compliance for review.

2. For UT test on shaft, defect echo < 20 % full screen height when back wall echo set @ 100 % screen height. Reduction in back wall echo to be <20%.
Defect height > 20 % of FSH is not acceptable, also loss in backwall echo>20 % not acceptable.

3. IP 68 protection certificate for test conducted on similar motor shall be submitted for review

4. Compliance for provision of thermic switch for over heating protection of winding, reverse rotation protection device shall be submitted by Manufacurer

5. For control panel separate QAP is applicable.

6. Before sending the documents for approval, supplier to ensure that "Reference documents" & "acceptance Norms" does contain data required for the Characteristic to be checked" as indicated in QP.

			LEGEND: RECORDS IDENTIFIED WITH "NCK" ( ) SHALL BE	BHEL DOC No.:PE : V8 - XXX - 100-N005
			ESSENTIALLY INCLUDED BY SUPPLIER IN QA DOCUMENTATION	
		BHEL	** **M:** MANUFACTURER/SUB CONTRACTOR	NAME AND SIGN OF APPROVING AUTHORITY AND SEAL
	MANUFACTURER/	CONTRACTOR	**B**: BHEL, **C**:CUSTOMER (END USER)	
	SUBCONTRACTOR		**P :** PERFORM **W:** WITNESS **V :** VERIFICATION AS APPROPRIATE	
	SIGNATURE			

ENGG DIV / QA & I

	MANUFACTURERS NAME & ADDRESS	STANDARD QUALITY PLAN		PROJECT
	(AS PER BHEL APPROVED VENDOR LIST)	ITEM: Chain Pulley Block With Trolley	QP NO REV 0 DATE 20.02.2001 PAGE 1 of 3	PACKAGE PROJECT No CONTRACTOR

Sl. No	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD	D*	AGENCY M	AGENCY C	AGENCY N	REMARKS
1	2	3	4	5	6	7	8	9		** 10			11
1	**RAW MATERIAL & B/OUT ITEMS:**												
1.1	HOOKS	DIMENSIONS	MA	MEASUREMENT		IS 8610 GR M/P	IS 8610 GR M/P	T.C.		P	-	-	
		CHEMICAL COMPOSITION	MI	LAB ANALYSER									
		IDENTIFICATION & CORELATION WITH TC	MA	VERIFICATION		DRAWING	DRAWING & SPECIFCATION						
1.2	LOAD CHAIN	DIMENSIONS		MEASUREMENT	100%	IS 6216	IS 6216	MFR'S TC		P	-	-	
		BREAKING STRENGTH		TENSILE TEST									
1.3	RAW MATL FOR GEAR/RATCHET	CHEMICAL COMPOSITION	MA	LAB ANALYSIS	ONE SAMPLE	SPECS AS PER	RELEVANT	TC					
	PAWL/RATCHET WHEEL				PER LOT	APPD. DRG.	STANDARD			P			
1.4	LOAD CHAIN WHEELS	TENSILE STRENGTH	MA	TENSILE TEST	ONE SAMPLE PER LOT	SPECS AS PER APPD. DRG.	RELEVANT STANDARD	TC		P			

LEGNDS

* RECORDS INDENTIFIED WITH 'TICK'( ) SHALL BE ESSENTIALLY INCLUDED BY CONTRACTOR IN QA DOCUMENTATION

** M: MANUFACTURER/SUBCONTRACTOR
C: CONTRACTOR NOMINATED INSPECTION AGENCY(BHEL)
N: CUSTOMER
INDICATE 'P' PERFORM"W" WITNESS AND "V" VERIFICATION AS APPROPRIATE " CHP" CUSTOMER SHALL IDENTIFY IN COLUMN"N"

MANUFACTURER/ SUB CONTRACTOR	CONTRACTOR	REVIEWED BY	
SIGNATURE			NAME & SIGN OF APPROVING AUTHORITY &SEAL

	MANUFACTURERS NAME & ADDRESS	**STANDARD QUALITY PLAN**		PROJECT
	(AS PER BHEL APPROVED VENDOR LIST)	ITEM: Chain Pulley Block With Trolley	QP NO	PACKAGE
			REV 0	PROJECT No
			DATE 20.02.2001	CONTRACTOR
			PAGE 2 of 3	

Sl. No	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD	D*	AGENCY M	AGENCY C	AGENCY N	REMARKS
1	2	3	4	5	6	7	8	9		** 10			11
2	PROCESS												
2.1	HOOKS	PROOF LOAD	MA	LOAD TEST	100%	IS 8610	IS 8610	IR		P	W		
		DPT AFTER PROOF LOAD	MA		100%	ASTM 709	ASTM 709	IR		P	W		
2.2	RACHET PAWL/RACHET WHEEL	HARDNESS	MA	HARDNESS TESTER	100%	IS :1832	IS : 3832	IR		P	W		
		SURFACE CRACKES	MA	DPT	100%	ASTME				P	W		
2.3	LOAD CHAINS	PROOF - LOAD	MA	LOAD TEST	100%	IS : 6216	IS:6216	MFR'S		P			
3	FINAL INSPECTION												
3.1	COMPLETE ASSEMBLY	PROOF LOAD TEST	CR	LOAD TEST	100%	IS: 3832	IS: 3832	IR		P	W	W	
		OPERATIONAL EFFORT	MA	LOAD TEST	RANDOM	IS: 3832	IS: 3832	IR		P	W	W	
		HEIGHT OF LIFT	MA	MEASUREMENT	100%	IS: 3832	IS: 3832	IR		P	W	W	
		SWIVELLING OF HOOK	MA	VISUAL	100%	IS: 3832	IS: 3832	IR		P	W	W	

LEGNDS

* RECORDS INDENTIFIED WITH 'TICK'( ) SHALL BE ESSENTIALLY INCLUDED BY CONTRACTOR IN QA DOCUMENTATION

** M: MANUFACTURER/SUBCONTRACTOR

C: CONTRACTOR NOMINATED INSPECTION AGENCY(BHEL)

N: CUSTOMER

INDICATE 'P' PERFORM"W" WITNESS AND "V" VERIFICATION AS APPROPRIATE " CHP" CUSTOMER SHALL IDENTIFY IN COLUMN"N"

MANUFACTURER/ SUB CONTRACTOR	CONTRACTOR	REVIEWED BY	
SIGNATURE			NAME & SIGN OF APPROVING AUTHORITY &SEAL

	MANUFACTURERS NAME & ADDRESS	STANDARD QUALITY PLAN		PROJECT
	(AS PER BHEL APPROVED VENDOR LIST)	ITEM: Chain Pulley Block With Trolley	QP NO REV 0 DATE 20.02.2001 PAGE 3 of 3	PACKAGE PROJECT No CONTRACTOR

Sl. No	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD	D*	AGENCY M	AGENCY C	AGENCY N	REMARKS
1	2	3	4	5	6	7	8	9		** 10			11
3.2	PAINTING	CLEANED	MA	VISUAL	AT RANDOM	SPEC.	PE	IR		P	-	-	
		SHADE OF PAINT GOLDEN YELLOW	MA	VISUAL	AT RANDOM	SPEC.	PE	IR		P	W	W	
3.3	NAME PLATE	VERIFICATION	MI	VISUAL	100%	PR	PR	IR		P	W	-	
3.4	PACKING	VERIFICATION	MI	VISUAL	100%	PR	PR	IR		P	W	-	

LEGNDS

* RECORDS INDENTIFIED WITH 'TICK'( ) SHALL BE ESSENTIALLY INCLUDED BY CONTRACTOR IN QA DOCUMENTATION

** M: MANUFACTURER/SUBCONTRACTOR

C: CONTRACTOR NOMINATED INSPECTION AGENCY(BHEL) N: INDICATE 'P' PERFORM"W" WITNESS AND "V" VERIFICATION AS APPROPRIATE " CHP" NTPC SHALL IDENTIFY IN COLUMN"N"

MANUFACTURER/ SUB CONTRACTOR	CONTRACTOR	REVIEWED BY	NAME & SIGN OF APPROVING AUTHORITY &SEAL
SIGNATURE			

STANDARD QUALITY PLAN

PROJECT :
VENDOR :

SYSTEM :
ITEM : BUTERFLY VALVES

S N	COMPONENT / OPERATION	CHARACTERISTICS CHECKED	CAT. EGO-RY	TYPE / METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
1	2	3	4	5	6	7	8	9		10		11
1.0	RAW MATERIAL BOUGHT-OUT CONTROL											
1.1	BODY & SHAFT SEAT RING	1.CHEM COMPOSITION & PHYS. PROPS	MA	CHEM. & PHYS TESTS	ONE/HEAT BATCH	TECH SPEC APPD DRG	TECH SPEC / APPD DRG.	LAB REPORT / INSPN REPORT	3/2	-	2.1	CORRELATION NOT REQUIRED FOR GREY C.I. FOR OTHER POURING WITNESS BY BHEL
		2.INTERNAL DEFECTS OF SHAFT DIA ≥ 50MM	CR	UT	100%	ASTM A388 & XE 100%		INSPN. REPORT	3/2	2.1	-	MATERIAL IDENTIFICATION OF SHAFTS BY BHEL NOTE. COMPLIANCE TO EQ-MS & GI CORRELATION & IDENTIFICATION FOR SS
		3.CASTING DEFECTS/ FORGING DEFECT	MA	1. VISUAL 2. MPI	100% 100%	MSSSP65 TECH. SPEC. APPD DATA SHEET	MSSSP55 TECH. SPEC / APPD DATA SHEET	-DO-	3/2	-	2.1	
1.2	DISC & SHAFT SEAL	1. VISUAL INSPECTION	MA	VISUAL	100%	TECH SPEC	TECH. SPEC	LOG BOOK	3/2	-	-	COMPLIANCE TO
		2. DIMENSIONS	MA	MEAS	100%	-DO-	-DO-	-DO-	3/2	-		
		3. HARDNESS	MA	MEAS	100%	-DO-	-DO-	TEST CERT.	3/2	-		
		4. O ZONE RESISTANCE	MA	TESTING	1/BATCH	-DO-, ASTM D1149	-DO-, RELV. STD.	-DO-	3/2	-		
		5. AGEING TEST	MA	TESTING	-DO-	IS 3400	-DO-	-DO-	3/2	-		
1.3	COUNTER FLANGES	1. CHEM., PHYS. PROPERTIES	MA	CHEM. PHYS. TEST	1/HEAT	APPD. DRG. /DATA SHEET	APPD. DRG. /DATA SHEET	LAB. REPORT, INSPN. REPORT	3/2	-	-	COMPLIANCE TC FOR MATERIAL IDENTIFICATION BY BHEL

		PREPARED BY	REVIEWED BY	APPROVED BY	ACCEPTED BY
O.P NO	PEM/MSE/SQP/03	PEM	CQS & PEM	PEM	VENDOR
REV. NO/DATE	00/8-10-97	NAME			NAME
		SIGNATURE			SIGN.
PAGE NO	1 OF 7	DATE			DATE

BHARAT HEAVY ELECTRICALS LIMITED
PROJECT ENGINEERING MANAGEMENT

STANDARD QUALITY PLAN

PROJECT :
VENDOR

SYSTEM :
ITEM BUTERFLY VALVES

S. NO	COMPONENT / OPERATION	CHARACTERISTICS CHECKED	CAT-EGO-RY	TYPE / METHOD OF CHECK	EXTE-NT OF CHEC	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
1	2	3	4	5	6	7	8	9		10		11
		2 DIMENSION	MA	MEASURE-MENT	100%	-DO-	-DO-	INSPN. REPORT	3/2	2 1	-	
		3. INTERNAL DEFECTS FOR THICKNESS 50MM AND ABOVE	CR	UT	100%	ASTM A435	ASTM A435	INSPN. REPORT	3/2	2 1	-	
		4 HEAT TREATMENT		SR/M.T CHART	100%	STANDARD PRACTICE	STANDARD PRACTICE	CORRELATED SR/M.T. CHART	3/2	-	-	
4	FASTENERS (APPD MAKE	1 VERIFICATION OF MAKE GRADE	MI	VISUAL	100%	TECH SPEC /DATA SHEET	TECH SPEC DATA SHEET	INSPN. REPORT	3/2	2	1	
5	OPERATORS (GEAR BOX GE	COMPOSITION	MA	CHEM ANALYSIS	ONE/BATCH	AS PER MATERIAL SPEC	AS PER MATERIAL SPEC	TC'C'	3	3	2/1	
5 1	GEAR / PINION, SHAFT	HARDNESS	MA	MEAS	SAMPLING	AS PER APPD DRG /MATL SPEC	AS PER APPD DRG /MATL SPEC	TC'C'	3	3	2/1	
		DIMENSION	MA	-DO-	-DO-	-DO-	-DO-	REPORT	3	3	2/1	UT ON GEAR BLANKS
		NDT	MA	UT/MPI	100%	-DO-	-DO-	TC'C'	3	3/2	2/1	UT ON SHAFTS & SCREW DIA
5 2	HYDRO. TEST OF GEAR B (FOR 2) RATED TORQUE	TORQUE TRANSMITTING	MA	TESTING	ONE/TYPE	AWWA C504 STD 87	AWWA C504 STD 87	TC'C CHP	3	3/2	2/1	MPI OR LPI ON GEAR & SHAFT AFTER MACHINING
												NO DAMAGE TO TEETH FACE OF GEAR
5 3	ELECTRICAL ACTUATORS	1 TORQUE TESTING & SETTING OF TORQUE SWITCH	MA	MECH /ELEC TESTS	100%	TECH SPEC /APPD DRG /DATA SHEET/ IS 9334	APPD DRG /DATA SHEET/IS 9334	INSPN REPORT	3	2 1	-	BHEL TO WITNESS 1 PER TYPE IF QTY IS MORE THAN 10/TYPE

			PREPARED BY	REVIEWED BY	APPROVED BY		ACCEPTED BY
			PEM	CQS & PEM	PEM		VENDOR
Q.P NO	PEM/MSE/SQP/03	NAME				NAME	
REV NO/DATE	00/8-10-97	SIGNATURE				SIGN.	
PAGE NO.	2 OF 7	DATE				DATE	

BHARAT HEAVY ELECTRICALS LIMITED
PROJECT ENGINEERING MANAGEMENT

STANDARD QUALITY PLAN

PROJECT :
VENDOR :

SYSTEM :
ITEM : BUTERFLY VALVES

NO	CHECK / OPERATION	CHARACTERISTICS CHECKED	CAT-EGO-RY	TYPE / METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY	REMARKS
1	2	3	4	5	6	7	8	9		10		
		2 TRAVEL/STROKE	MA									
		3 TRAVEL TIME	MA									
		4 OPERATION OF LIMIT SWITCH										
		5 MANUAL OPERATION THROUGH HAND WHEEL	MA									
		6 OPERATION TEST WITH POWER SUPPLY VARIATION, ENERGISE TO OPEN/CLOSE, CURRENT DRAWN	MA									
		7 IR, HV, IR	MA									
		8 DEGREE OF PROTECTION	MA	WATER DUST TEST	1/TYPE	-DO-	-DO-	3rd PARTY TEST CERT	3	-	2.1	
6	HYD. [illegible]	1 CHEM & PHYS. PROPS	MA	CHEM. PHYS TESTS	1/HEAT/ BATCH	APPD. DRG. /DATA SHEET	APPD. DRG. /DATA SHEET	TEST CERT	3/2	-	2.1	
		2. HARDNESS	MA	MEAS	100%	-DO-	-DO-	-DO-	3/2	-	2.1	
		3 DIMENSIONS	MA	MEAS.	100%	MFG. DRG	MFG. DRG.	LOG BOOK	3/2	-	-	
		4. LEAK TIGHTNESS	MA	HYDRO TEST	100%	APPD. DATA SHEET	NO LEAKAGE	INSPN. REPORT	3/2	2.1	-	
	[illegible]	1. CHEM., PHYS. PROPS.	MA	CHEM., PHYS. TESTS	1/HEAT	APPD. DATA SHEET	APPD. DATA SHEET	TEST CERT.	3/2	2	1.1	
		2. DIMENSION	MA	MEASURE-MENT	100%	MFG. DRG.	MFG. DRG.	LOG SHEET	3/2	-	-	

			PREPARED BY	REVIEWED BY	APPROVED BY		ACCEPTED BY
Q.P. NO	PEM/MSE/SQP/03		PEM	CQS & PEM	PEM		VENDOR
REV. NO DATE.	00/8-10-97	NAME				NAME	
		SIGNATURE				SIGN	
PAGE NO	3 OF 7	DATE				DATE	

BHARAT HEAVY ELECTRICALS LIMITED
PROJECT ENGINEERING MANAGEMENT

STANDARD QUALITY PLAN

PROJECT :
VENDOR :

SYSTEM :
ITEM : BUTERFLY VALVES

S NO	COMPONENT / OPERATION	CHARACTERISTICS CHECKED	CATEGORY	TYPE / METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
1	2	3	4	5	6	7	8	9		10		11
	CLIP SHAFT	1 CHEM PHYS PROPS	MA	CHEM PHYS TESTS	1/BATCH	MATL SPEC /APPD ORG.	MATL SPEC /APPD ORG	LOG BOOK	3/2	2	1	
		2 DIMENSIONS	MA	MEAS.	100%	MFG ORG.	MFG ORG	-DO-	3/2	2	1	
		3 HARDNESS	MA	MEAS	100%	-DO-	-DO-	TEST CERT	3/2	2	1	
2.0	IN-PROCESS CONTROL											
2.1	BODY & DISC	1 SURFACE DEFECTS	MA	PT	100%	ASTME-165	NO DEFECTS	INSPN REPORT	3/2	2	1	
		2 DIMENSIONS	MA	MEAS	100%	MFG ORG	APPD ORG	LOG BOOK	3/2	-	-	
		3 LEAK TIGHTNESS OF BODY	MA	HYDRO TEST	100%	TECH. SPEC /APPD ORG /DATA SHEET	NO LEAKAGE	INSPN REPORT	3/2	-	2.1	
2.2	SHAFT	1 DIMENSIONS	MA	MEAS	100%	MFG ORG	APPD ORG	LOG BOOK	3/2	-	-	
		2 SURFACE DEFECTS AT SEAL	MA	PT	100%	ASTME-165	NO SURFACE DEFECTS	INSPN REPORT	3/2	-	2.1	
2.3	SEAT RING	1 DIMENSIONS	MA	MEAS	100%	MFG ORG	APPD ORG	LOG BOOK	3/2	-	-	
		2 BOND STRENGTH IN CASE OF RUBBER SEAT	MA	PEEL STRENGTH	ONE/BATCH	ASTMD 429	ASTMD429	TEST CERT	3/2	-	2.1	
		3 HARDNESS	MA	MEAS	100%	MFG ORG	MFG ORG	-DO-	3/2	2	1	

			PREPARED BY	REVIEWED BY	APPROVED BY	ACCEPTED BY
			PEM	CQS & PEM	PEM	VENDOR
Q.P. NO.	PEM/MSE/SOP/03	NAME				NAME
REV NO/DATE	00/8-10-97	SIGNATURE				SIGN.
PAGE NO.	4 OF 7	DATE				DATE

209

BHARAT HEAVY ELECTRICALS LIMITED
PROJECT ENGINEERING MANAGEMENT

STANDARD QUALITY PLAN

PROJECT :
VENDOR :

SYSTEM :
ITEM : BUTERFLY VALVES

S NO	COMPONENT OPERATION	CHARACTERISTICS CHECKED	CATEGORY	TYPE / METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
1	2	3	4	5	6	7	8	9		10		11
		4 SURFACE DEFECTS	MA	PT	100%	ASTME 165	NO SURFACE DEFECTS	-DO-	3/2	2	1	
			MA	PHYS TESTS	100%	ASME IX	ASME IX	FORMATS OF ASME IX	3/2	2,1	1	
2.4	WELDED FLANGES/COUNTER FLANGES											
		1 FIT UP	MA	MEAS, TEMPLATE, VISUAL	100%	MFG DRG	MFG DRG	LOG BOOK	3/2		2,1	FOR FABRICATED FLANGES ONLY FILMS TO BE SHOWN TO BHEL
		2 INTERNAL DEFECTS OF WELDMENTS	CR	RT/UT	100%	ASME VIII DIV. I	ASME VIII DIV I	RADIO GRAPH REPORT FILMS	3		2,1	
2.4.1	WELDING PROCEDURE SPECIFICATION	CORRECTNESS	MA	EXAM	100%	ASME SEC IX	ASME SEC IX	QW 482 OF ASME SEC IX	3/2		2,1	
2.4.2	WELDING PROCEDURE QUALIFICATION	WELD SOUNDNESS	MA	VISUAL, PHYS. TESTS RT (AS APPLICABLE)	100%	ASME SEC IX	ASME SEC IX	QW 483 OF ASME IX	3/2	2,1		WELDING PROCEDURE APPROVED BY BHEL AS WELL AS 3RD PARTY (LLOYDS, BVQI OR EQ.)
2.4.3	WELDER PERFORMANCE QUALIFICATION	WELL SOUNDNESS	MA	-DO-	100%	ASME SEC. IX	ASME SEC. IX	QW 484 OF ASME	3/2	2,1		

			PREPARED BY	REVIEWED BY	APPROVED BY	ACCEPTED BY
Q.P. NO.	PEM/MSE/SQP/03		PEM	QCS & PEM	PEM	VENDOR
REV. NO/DATE	00/8-10-97	NAME				NAME
		SIGNATURE				SIGN
PAGE NO.	5 OF 7	DATE				DATE

BHARAT HEAVY ELECTRICALS LIMITED
PROJECT ENGINEERING MANAGEMENT

STANDARD QUALITY PLAN

PROJECT
VENDOR

SYSTEM :
ITEM : BUTERFLY VALVES

S NO	COMPONENT / OPERATION	CHARACTERISTICS CHECKED	CATEGORY	TYPE / METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
1	2	3	4	5	6	7	8	9		10		11
2.4.4	WELD FIT-UPS	1 DIMENSION/ALIGNMENT	MA	MEAS, VISUAL EXAM	100%	WPS, MFG. DRAWING	WPS, MFG. DRAWING	IR/LOG BOOK	3/2	-	-	
2.4.5	ROOT RUNS	1 SURFACE DEFECTS	MA	PENETRANT TEST	100%	ASTME 165	NO SURFACE DEFFECT	-DO-	3/2	-	2	
2.4.6	WELDMENTS	1 SURFACE DEFECTS	MA	-DO-	100%	ASTME 165	ASME-VIII, DIV. I,	INSPN REPORT	3/2	2,1	-	
2.4.7	BUTT WELDS	INTERNAL DEFECT	MA	UT/RT	100%			IR	3/2	-	2,1	WITNESSING OF U T
2.4.8	SR WELDING	SR	-	SR	100%	ASME SEC. V	ASME SEC VIII, DIV I	IR	3,2	-	2,1	
3.0	FINAL ASSEMBLY											
3.1	VERIFICATION OF ALL PREVIOUS TEST AND DOCUMENTS	VERIFICATION OF RECORDS	MA	-DO-	100%	TECH. SPEC.	TECH. SPEC		2	-	1	
3.2	TESTS (HYDRAULIC)	1 BODY TEST 2 DISC STRENGTH 3 SEAT LEAKAGE 4 PERFORMANCE TEST	MA MA MA MA	HYDRO TEST HYDRO TEST -DO- PERFORMANCE	100% 1/TYPE 100% 3 TIMES UNDER NO LOAD/FLOW COND. BOTH MANUAL & THROUGH OPERATORS	TECH. SPEC /REL. STD -DO- -DO- -DO-	TECH /SPEC / REL. STD -DO- -DO- -DO-	TEST CERT. -DO- -DO- -DO-	3,2 3/2 3/2 3,2	2,1 2,1 2,1 2,1	- - - -	

			PREPARED BY	REVIEWED BY	APPROVED BY	ACCEPTED BY
			PEM	CQS & PEM	PEM	VENDOR
O.P NO	PEM/MSE/SQP/03	NAME				NAME
REV NO/DATE	00/8-10-97	SIGNATURE				SIGN.
PAGE NO.	6 OF 7	DATE		2.11		DATE

BHARAT HEAVY ELECTRICALS LIMITED
PROJECT ENGINEERING MANAGEMENT

STANDARD QUALITY PLAN

PROJECT
VENDOR

SYSTEM
ITEM BUTERFLY VALVES

	COMPONENT / OPERATION	CHARACTERISTICS CHECKED	CATEGORY	TYPE / METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
2		3	4	5	6	7	8	9				11
		5 TESTING OF ACCESSORIES	MA	TESTING	100%	TECH SPEC /REL STD	TECH SPEC /REL STD	TC	3.2	2		
		6 PROOF OF DESIGN TEST	MA	TESTING	1 TYPE	DO.	DO.	TC	3.2	2		NOTE: IF CYCLE LIFE TEST ALREADY CONDUCTED ON SIMILAR SIZE, RANGE & VALVE REPORT SHALL BE SUBMITTED
4	SHIPPING RELEASE											
5	FINAL INSPECTION	1 OVERALL DIMENSIONAL	MA	MEASUREMENT	100%	APPD DRG	APPD DRG		3.2	2		
		2 DOCUMENTATION VIEW	MA	REVIEW	100%	TECH SPEC APPD DRG	TECH SPEC APPD DRG		3.1			
		3 CLEANLINESS	MA	VISUAL	100%	DO.	DO.		3.2	2		
		4 NAME PLATE DETAILS	MA	VISUAL	100%	DO	DO		3.1			
		5 STAMPING	MA	STAMPING	100%	DO.	DO.					
6	PAINTING	1 SURFACE PREP	MI	VISUAL, MEAS.	100%	TECH SPEC	TECH SPEC	INSPN REPORT	3.2		2.1	
		2 UNIFORMITY & THICKNESS	MI	DO.	100%	DO.	DO.	DO.	3.2		1	

			PREPARED BY	REVIEWED BY	APPROVED BY		ACCEPTED BY
			PEM	CQS & PEM	PEM		VENDOR
Q.P. NO.	PEM/MSE/SQP/03	NAME				NAME	
REV NO/DATE	00/8-10-97	SIGNATURE				SIGN	
PAGE NO	7 OF 7	DATE				DATE	

SUB-SECTION - IIB

STANDARD TECHNICAL SPECIFICATION (ELECTRICAL)

CONTENT

CLAUSE NO.	DESCRIPTION
1.00.00	SCOPE OF SUPPLY
2.00.00	CODES & STANDARDS
3.00.00	DESIGN CRITERIA
4.00.00	SPECIFIC REQUIREMENTS
5.00.00	TESTS
6.00.00	DRAWINGS DATA & MANUALS

ATTACHMENTS

ANNEXURE-A	RATINGS AND REQUIREMENTS - H.V POWER CABLES (11KV & 3.3 KV)
ANNEXURE-B	RATINGS AND REQUIREMENTS - L.V POWER CABLES
ANNEXURE-C	RATINGS AND REQUIREMENTS - CONTROL CABLES
ANNEXURE-D	RATINGS AND REQUIREMENTS - 1.1KV FS POWER & CONTROL CABLE
ANNEXURE-E	RATINGS AND REQUIREMENTS - FLEXIBLE TRAILING CABLES
ANNEXURE-F	CABLE SIZES

SECTION-IV

TECHNICAL SPECIFICATION FOR CABLES

1.00.00 **SCOPE OF SUPPLY**

1.01.00 Power and Control Cables shall cover the requirement of entire Plant including the switchyard.

Other cables including special cables, if any, which may be necessary as per proven engineering practice for satisfactory and trouble free operation of the entire cable system of the plant shall also be within the scope of supply. These shall include all such cables for electrical integral with mechanical equipment systems and subsystems.

1.02.00 Cable shall be furnished in accordance with this specification and the following annexures :

a)	11kV & 3.3 kV Power cables	:	Annexure - A
b)	1100V Power Cables	:	Annexure – B
c)	Control Cables	:	Annexure – C
d)	Fire Survival Cables	:	Annexure – D
e)	Flexible Trailing cable	:	Annexure – E

1.03.00 All relevant drawings, data and instruction manuals

2.00.00 **CODES & STANDARDS**

2.01.00 All cable and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) and IEC except where modified and/or supplemented by this specification.

2.02.00 Cable and material conforming to any other standard which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

2.03.00 The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

3.00.00 **DESIGN CRITERIA**

3.01.00 Cables will be generally laid on ladder type trays or drawn through rigid PVC/GI /HDPE pipe/conduits. Cable tunnels shall be avoided as far as possible, except at locations where overhead trays are not possible, with prior approval of the Owner.

3.02.00 For continuous operation at specified rating, maximum conductor temperature shall be limited to the permissible value as per relevant standard and/or this specification which one is more stringent.

3.03.00 The insulation and sheath materials shall be resistant to oil, acid and alkali and shall be tough enough to withstand mechanical stresses during handling.

3.04.00 Armouring shall be single round wire of galvanized steel for multicore cables and aluminum for single core cable for power and control cables. For fire survival control cable, the armouring over inner sheath shall consist of single layer of wire / round galvanised steel wire as per IS 3975 amended upto date. For Fire survival power cable, Single core cables to be used in A.C. system, the armouring over inner sheath shall consist of single layer of round copper wire, for multi-core cables to be used in A.C. system and single core cables in D.C. System, the armouring over inner sheath shall consist of single layer of round galvanised steel wire.

3.05.00 The outer sheath shall have flame retardant low smoke halogen evolution (FRLSH) characteristics or fire survival characteristics as applicable and shall meet the requirements of additional tests specified for the purpose.

3.06.00 Core identification for multicore cable shall be provided by colour coding.

3.07.00 HT cables shall be manufactured by triple extrusion dry cured (CCV) process using pressurized nitrogen.

4.00.00 SPECIFIC REQUIREMENTS

4.01.00 General Description

All Cables shall be furnished in strict compliance with ratings and requirements and sizes as given in Annexures to this Specification.

4.02.00 Drum Length and Tolerance

The cables shall be supplied in non-returnable packing steel drum for 11 kV & 3.3 kV power cables, wooden drums for 1100V power and control cables, each containing minimum 500 meters length of larger sizes of cable unless specifically asked for. For smaller sizes of cables, each drum shall contain 1000 meters length of cable. Allowable tolerance on individual drum length is $\pm$5%.

4.03.00 Non-Standard Length

Non-standard lengths upto 5% of the total ordered quantity may be accepted. However the Contractor will be required to obtain approval before packing the Cables on drums. Non-standard lengths shall not be less than 100 metres in any case.

4.04.00 Cable identification

Cable identification shall be provided by embossing on every meter on the outer sheath the following :

a) TSGENCO

b) Manufacturer's name or trade mark

c) Voltage grade

d) Year of manufacture

e) Type of insulation, e.g. XLPE/PVC/HR85/IE2 etc.

f) No. of core and size of cables.

g) Type of improved fire performance, e.g. FR/FRLSH/FS

h) IS number

4.05.00 **Packing**

4.05.01 Cables shall be supplied in non returnable drums. The drums shall be of heavy construction. All wooden parts shall be manufactured from seasoned wood. All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. Wooden cable drum shall be treated by immersing in copper-nitrate solution.

4.05.02 Cable shall be wound and packed on drums in such a manner that it will be properly sealed and firmly secured to the drum. The ends of each length shall be sealed before shipment.

4.05.03 The cable drums should carry the following details in printed form:

a) TSGENCO

b) Manufacturer's name or trade make

c) Type of cable & voltage grade

d) Year of manufacture

e) Type of insulation e.g. XLPE/HRPVC/IE2

f) No. of core and size of cables

g) Cable code e.g. FRLSH/FS

h) Length of cable on drum

i) No. of length on drum, if more than one

j) Direction of rotation, by arrow

k) Approx. gross mass.

l) IS/IEC number and ISI mark

4.06.00 **Joints and Terminations**

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. Straight through joints and terminations for HT cables shall be heat shrinkable type.

4.07.00 **Selection Criteria**

4.07.01 a) HT and LT power cables shall be selected on the basis of current carrying capacity, short circuit rating and permissible voltage drop.

b) While sizing power cables, following aspects shall be reckoned:

i) Ground/Ambient Air temperature

ii) Depth of Laying.

iii) Power Cables touching each other.

c) Cables, for circuit breaker controlled feeders, shall withstand the short circuit current for the fault clearing time 0.16 Sec. for outgoing feeder, 0.5 Sec. for Tie feeder and 1.0 Sec. for Incomer.

d) HT cables shall be sized based on the following considerations:

Rated current of the equipment and ground/ambient temperature.

Touching/spacing of cable.

Laying on multi-tier racks, trench

Depth of laying.

The voltage drop of the cable , during motor starting condition , shall be limited to 15% and during full load running condition shall be limited to 3 % rated voltage. For BFP motor, the voltage drop during motor starting condition shall be limited to 20% and for Mill motor shall be limited to 10%. Other outgoing feeder / transformer feeder shall be limited to 3% rated voltage.

Short circuits withstand capability

e) For fuse/MCCB/Breaker protected circuits the conductor size shall depend upon full load current subject to voltage drop limited to 3% during running of all feeders and 15% during starting for motor feeders. In addition, transformer regulation shall also be considered for loads fed from 415V PMCC. Incase of other out going line feeder voltage drop shall be limited to 3%.

f) For loads fed from local panels, the total running voltage drop in cable from 415V PMCC to local panel and from local panel to individual motor shall be limited to 3% at full load motor current while the same during starting shall be limited to 15%.

g) As per national electric code (NEC) current rating capacity of motor feeder/cables should be 125% of full load current.

h) For welding receptacle, 3% running drop shall only be considered.

The minimum sizes of L.T cable to be chosen are as below:

AL - 16 mm^2 (3 core) & 16mm^2 (2 core) Cu - 2.5 mm^2

4.07.02 Apart from above, consideration shall also be given to limit the cable to some standard sizes instead of using too many types.

4.07.03 The standard cable sizes, amp capacities, derating factors. as given in IS/IEC will be generally followed.

4.07.04 a) For breaker protected circuits minimum size of the cable shall be as follows:

1100V Power Cable	:	240 Sq mm XLPE AL
3300V Power Cable	:	185 Sq mm XLPE AL
11000V Power Cable	:	240 Sq mm XLPE AL

b) For motor circuits the selection of size will be made ensuring that the cable shall withstand a short circuit fault directly following a second hot start.

4.07.05 For fuse/MCCB protected circuit, the conductor size will depend on full load current subject to voltage drop not exceeding 3%. For practical purposes, the minimum size chosen is as below :

a)	Aluminium	:	6 Sq mm.
b)	Copper	:	2.5 Sq mm.

4.07.06 All control cables shall be 2.5 Sq mm copper cable.

4.07.07 Multicore control cables will generally have spare conductor (s) in accordance with the following chart :

Conductors required	**Cables**
1 or 2	1-3/C
3 or 4	1-5/C
5 or 6	1-7/C
7 or 8	1-9/C

9 or 10	1-12/C
Above 10	Two or more of above cables

4.07.08 Separate cables for each type of following services/functions as applicable shall be used for each feeder. Same multicore cable using different services shall not be acceptable.

a) Power.

b) Control, interlock and indication.

c) Metering and measuring.

d) Alarm and annunciation.

e) C.T. Cables.

f) V.T. Cables.

4.08.00 **Cable Identification**

Cable identification shall be provided by embossing on the outer sheath the following :

a) Manufacturer's name or trade mark

b) Manufacturer's name or trade mark

c) Voltage grade

d) Year of manufacture

e) Type of insulation, e.g. XLPE, HRPVC & IE2 etc.

f) No. of core & size of cables

g) Type of outer sheath e.g. FRLSH, FS etc.

4.09.00 Selected sizes of power and control cables are given in Annexure-G.

4.10.00 Fire Survival Cables shall be used for important auxiliaries / area as recommended in Standard Technical Specification by CEA for the following services. The fire survival time of these cables shall not be less than 3 hours at 750 deg. C.

i. DC emergency lube oil pump

ii. DC hydrogen seal pump

iii. Turbine lube oil pump/barring gear

iv. DC emergency lighting for main building and service building

v. DC cables for battery to charger & DC distribution boards

vi. Jacking oil pump

vii. Emergency turbine trip in control room

viii. Boiler Turbine : Generator inter trip which include the interconnection between

- Boiler master fuel trip and turbine trip relays
- Generator trip relays & turbine trip relays
- Generator trip relays & generator breaker
- Generator trip relays & field breaker
- Generator trip relays & unit auxiliary transformer breaker
- Incomer cables for DG board, emergency board, DC lighting board etc.

5.00.00 **TESTS**

5.01.00 **Shop Tests**

The Cables shall be subject to shop tests in accordance relevant IS/IEC standards to prove the design and general qualities of the Cables as below:

5.01.01 Routine tests on each drum of cables.

5.01.02 Acceptance Tests on 1 drum out of every 10 drums chosen at random for acceptance of the lot for every size.

5.01.03 Type test on each type and size of cable, inclusive of measurement of armour DC resistance of power cables on one drum out of every 10 drums of cable.

5.02.00 **Additional Tests**

Following additional acceptance tests shall also be performed on each type of cables having outer sheath with improved fire performance (category C1, Type FR/ Category C2, Type FRLSH)

5.02.01 Oxygen index test (both C1 & C2)

The Oxygen index shall not be less than 29.

5.02.02 Temperature Index Test (both C1 & C2)

The measured value of temperature index shall be 21 at a temperature of 250°C for FRLS cables and 350°C for FS cables

5.02.03 Flame Retardance test on single cable and on bunched cables (both C1 & C2)

After the test, there should be no visible damages on the test specimen within 300mm from its upper end.

After burning has ceased, the cables should be wiped clean and the charred or affected portion should not have reached a height exceeding 2.5 meter above the bottom edge of the burner, measured at the front and rear of the cable assembly. 3 Hours fire rating test shall be carried out for FS cable as per IEC-331

5.02.04 Halogen acid gas evolution test (for Category C2)

The level of HCL evolved shall not exceed 20 per cent by weight. HCL evolved shall not be exceed 2% for FS cable.

5.02.05 Smoke density test (for Category C2)

The cables shall meet the requirements of light transmission of minimum 40% after the test. Minimum transmission shall be 80% for FS cable.

5.02.06 Test for specific optical density of smoke

The cables shall meet the requirements of IS/IEC.

5.02.07 Test for rodent & termite repulsion property

The test shall be carried out to note the presence of rodent and termite repelling chemical in PVC compound. Normal procedure is that a few chippings of the PVC compound are slowly ignited in a porcelain dish or crucible in a muffle furnace at about 600°C. The resulting ignited ash is boiled with a little ammonium acetate solution (10%). A drop of aqueous sodium sulphide solution is placed on a thick filter paper and it is allowed to soak. The spot is touched with a drop of above extract. A black spot indicates the presence of anti-termite & rodent compound.

Flammability test shall be carried on finished cables as per following standards-

a) Swedish Chimney test – SS: 424-14-75

b) IEEE std.383 – 1974 latest

c) IEC std. 332-1, 332-3 and IEC 331

6.00.00 **DRAWINGS, DATA & MANUALS**

6.01.00 Drawings, Data and Manuals shall be submitted with the bid and for approval/ reference and subsequent distribution after the issue of Letter of Intent in quantities and procedures as specified in General condition of contract and/or

6.02.00 **To be submitted with the Bid**

a) Manufacturer's catalogues giving cable construction details and characteristics.

b) Cable current ratings for different types of installation, inclusive of derating factors for ambient temperature, grouping etc.

c) Write-up on Manufacturer's recommended method of splicing, jointing, termination etc. of the cables.

d) Type test reports on 11 KV & 3.3 KV Power, LT FRLSH Power & control, FS power and control cables.

e) Filled-up proposal particulars.

6.03.00 To be submitted for Owner/Purchaser's Approval and Distribution

All relevant drawings and data pertaining to the equipment like GTP, QAP, etc. shall be submitted by the Bidder for the approval of Owner/Owner's consultant. Also refer clause no. 1.19.02(u) of Section-I of Volume – V-A: Technical Specifications for Electrical Equipment & Accessories.

ANNEXURE-A

RATINGS AND REQUIREMENTS
HV POWER CABLES (11 KV & 3.3 KV)

1.0 11000/11000V & 3300/3300V grade 90^0C continuous rating under normal condition and 250^0C rating under short circuit condition heavy duty XLPE power cable suitable for use in 11000V/3300V non-effectively earthed system conforming to following requirement and in line with IS-7098, IS-8130, IS-5831 & IS-3975, manufactured by Triple Extrusion Dry Cure (CCV) process using pressurized Nitrogen.

1.1	Conductor	:	Stranded and compacted aluminium conductor of grade H2 & class 2 for all sizes, generally conforming to IS: 8130.
1.2	Conductor Screen	:	Extruded semi-conducting compound.
1.3	Insulation	:	Extruded cross linked polyethylene (XLPE) conforming to IS: 7098 (Part-2)
1.4	Insulation Screen	:	Extruded semi-conducting compound with a layer of non-magnetic metallic tape. For single core armoured cables, the armouring shall constitute the metallic part of screening. The semi-conducting tape shall be easily strippable.
1.5	Core Identification	:	By coloured strips applied on (For three core cables) cores.
1.6	Inner Sheath	:	Extruded HRPVC/FRLS compound conforming to type ST2 of IS: 5831 for three core cables. Single core cables shall have inner sheath. Filler material shall also be of type ST2 PVC.
1.7	Armour	:	Galvanised single round steel wire armour for twin and multicore cables. Non-magnetic hard drawn aluminum single round wire conforming to H4 of IS-8130 latest for single core cables
1.8	Overall Sheath	:	Extruded FRLSH HRPVC compound conforming to type ST2 of IS: 5831.
1.9	Drum	:	Steel Drum

ANNEXURE-B

RATINGS AND REQUIREMENTS
LV POWER CABLES [1.1KV (XLPE TYPE)]

1.0 1100 V grade, 90ºC continuous rating under normal condition and 250°C under short circuit condition rating, XLPE heavy duty, power cable conforming to following requirement and in line with IS 7098 Part-I. IS 8130 & IS 5831 and IS 3975.

1.1	Conductor	:	Stranded and compacted plain aluminium of grade H2 and class 2 stranded, high conductivity annealed plain copper for cable sizes upto 2.5 mm^2 conforming to IS:8130.
1.2	Insulation	:	Extruded cross-linked polyethylene (XLPE) conforming to IS: 7098 (Part-1)
1.3	Core Identification	:	By color coding
1.4	Inner Sheath	:	Extruded HRPVC FRLS compound conforming to type ST2 of IS: 5831 for multicore cable. Single core cables shall have no inner sheath. Filler shall be of same material as of inner sheath i.e. ST2
1.5	Armour	:	Galvanized single round steel wire armour for twin and multicore cables. Non-magnetic hard drawn aluminum single round wire conforming to H4 of IS-8130 latest for single core cables
1.6	Overall Sheath	:	Extruded FRLSH HRPVC compound conforming to type ST2 of IS: 5831.
1.7	Drum	:	Conforming to IS-10418 (Wooden drum)

ANNEXURE-C

RATINGS AND REQUIREMENTS
CONTROL CABLES

1.0 1100 V grade 85ºC continuous rating under normal condition and 160°C under short circuit condition rating HRPVC Control cable (YWY) conforming to following requirement and in line with IS:1554, IS:8130, IS:5831 and IS:3975.

1.1	Conductor	:	Stranded, non-compacted & circular, high conductivity annealed plain copper, generally conforming to IS: 8130.
1.2	Insulation	:	Extruded HRPVC type-C compound conforming to IS: 5831. The minimum volume resistivity of insulation shall be 3.5×10^{14} ohm-cm at $27^{O}C$ and 3.5×10^{11} OHM-CM at $85^{O}C$.
1.3	Core Identification	:	By color coding and numbering at interval of 100mm or less
1.4	Inner sheath	:	Extruded HRPVC compound conforming to type ST2 FRLS of IS: 5831 for multicore cables. Single core cables shall have no inner sheath. Filler shall be of same material as of inner sheath i.e. ST2.
1.5	Armour	:	Galvanised single round steel wire for twin and multicore cables.
1.6	Overall sheath	:	Extruded FRLSH HRPVC compound conforming to type ST2 of IS: 5831.
1.7	Drum	:	Conforming to IS: 10418 (Wooden drum)

ANNEXURE-D

RATINGS AND REQUIREMENTS
(1.1KV GRADE COPPER CONDUCTOR FS POWER CABLES)

1100 V, copper conductor, heat resisting insulation, extruded inner sheath of low smoke and very low halogen content fire resisting material, single layer of copper wire armour for single core/ single layer of round galvanised steel wire for multicore, outer sheath of low smoke and very low halogen content fire resistant material, suitable for minimum temperature of 750 deg.C for 3 hours. The cables shall be in compliance with IEC-60331, Part 11.

RATINGS AND REQUIREMENTS
(1.1KV GRADE COPPER CONDUCTOR FS CONTROL CABLES)

1100 V, copper conductor, heat resisting insulation, extruded inner sheath of low smoke and very low halogen content fire resisting material, single layer of copper wire armour for single core/ single layer of round galvanised steel wire for multicore, outer sheath of low smoke and very low halogen content fire resistant material, suitable for minimum temperature of 750 deg.C for 3 hours. The cables shall be in compliance with IEC-60331, Part 11.

ANNEXURE-E

RATINGS AND REQUIREMENTS
FLEXIBLE TRAILING CABLES

i) 3300 V Unearthed Grade

Flexible trailing cable, annealed plain copper conductor, Class-5 of IS-8130, insulated with EPR, conductor and insulation shielded with EPR, cores screened with ATC wire braiding, cores laid up, HD CSP inner sheathed, proof cotton taped and FRLS HD CSP sheathed overall, conforming to IS:9968. Alternatively PCP sheathing may be acceptable.

ii) 1100 V Grade

1100 V Grade trailing cable shall be plain copper of Class-5 of IS-8130, heat resistant elastomeric compound based on EPR insulation, inner sheath of heat resistant elastomeric compound PCP sheath, nylon cord reinforcement and heat resistant, oil resistant and flame retardant heavy duty elastomeric compound FRLS CSP outer sheath.

ANNEXURE-F

CABLE SIZES

Following sizes are given as a general guideline. Standard sizes as per IEC/IS shall be adopted.

Sl. No.	Cable Size	Conductor	Insulation
1.0	**H. T. CABLES (11kV)**		
1.1	1 core 1000 sq.mm	AL	XLPE (FRLS)
1.1	1 core 630 Sq.mm	AL	XLPE (FRLS)
1.2	3 core 400 Sq.mm	AL	XLPE (FRLS)
1.3	3 core 240 Sq.mm	AL	XLPE (FRLS)
1.4	1 core 70 Sq.mm	AL	XLPE (FRLS)
1.0	**H. T. CABLES (3.3kV)**		
1.1	1 core 630 Sq.mm	AL	XLPE (FRLS)
1.2	3 core 300 Sq.mm	AL	XLPE (FRLS)
1.3	3 core 240 Sq.mm	AL	XLPE (FRLS)
1.4	3 core 185 Sq.mm	AL	XLPE (FRLS)
1.5	1 core 70 Sq.mm	AL	XLPE (FRLS)
2.0	**L. T. POWER CABLES**		
2.1	3 core 2.5 Sq.mm	CU	XLPE (FRLS)
2.2	2 core 16 Sq.mm	AL	XLPE (FRLS)
2.3	3 core 16 Sq.mm	AL	XLPE (FRLS)
2.4	4 core 16 Sq.mm	AL	XLPE (FRLS)
2.5	2 core 35 Sq.mm	AL	XLPE (FRLS)
2.6	3 core 35 Sq.mm	AL	XLPE (FRLS)
2.7	4 core 35 Sq.mm	AL	XLPE (FRLS)
2.8	3 core 70 Sq.mm	AL	XLPE (FRLS)

Sl. No.	Cable Size	Conductor	Insulation
2.9	3.1/2 core 70 Sq.mm	AL	XLPE (FRLS)
2.10	3 core 95 Sq.mm	AL	XLPE (FRLS)
2.11	3.1/2 core 95 Sq.mm	AL	XLPE (FRLS)
2.12	3 core 185 Sq.mm	AL	XLPE (FRLS)
2.13	3.1/2 core 185 Sq.mm	AL	XLPE (FRLS)
2.14	3 core 240 Sq.mm	AL	XLPE (FRLS)
2.15	3.1/2 core 240 Sq.mm	AL	XLPE (FRLS)
2.16	3 core 300 Sq.mm	AL	XLPE (FRLS)
2.17	3.1/2 core 300 Sq.mm	AL	XLPE (FRLS)
2.18	1 core 630 Sq.mm	AL	XLPE (FRLS)
3.0	**CONTROL CABLE**		
3.1	2 core 2.5 Sq.mm	CU	HRPVC (FRLS)
3.2	3 core 2.5 Sq.mm	CU	HRPVC (FRLS)
3.3	5 core 2.5 Sq.mm	CU	HRPVC (FRLS)
3.4	7 core 2.5 Sq.mm	CU	HRPVC (FRLS)
3.5	9 core 2.5 Sq.mm	CU	HRPVC (FRLS)
3.6	12 core 2.5 Sq.mm	CU	HRPVC (FRLS)
3.7	20 core 2.5 Sq.mm	CU	HRPVC (FRLS)
4.0	**FS POWER CABLES**		
4.1	3 core 2.5 Sq.mm	CU	EPR
4.2	2 core 16 Sq.mm	CU	EPR
4.3	3 core 16 Sq.mm	CU	EPR
4.4	4 core 16 Sq.mm	CU	EPR
4.5	2 core 35 Sq.mm	CU	EPR

Sl. No.	Cable Size	Conductor	Insulation
4.6	3 core 35 Sq.mm	CU	EPR
4.7	4 core 35 Sq.mm	CU	EPR
4.8	3 core 95 Sq.mm	CU	EPR
4.9	3.1/2 core 95 Sq.mm	CU	EPR
5.0	**FS CONTROL CABLE**		
5.1	2 core 2.5 Sq.mm	CU	EPR
5.2	3 core 2.5 Sq.mm	CU	EPR
5.3	5 core 2.5 Sq.mm	CU	EPR
5.4	7 core 2.5 Sq.mm	CU	EPR
5.5	9 core 2.5 Sq.mm	CU	EPR
5.6	12 core 2.5 Sq.mm	CU	EPR

VOLUME : V-B

SECTION-IX

TECHNICAL SPECIFICATION
FOR
ERECTION - CABLING, GROUNDING AND LIGHTNING PROTECTION SYSTEM

CONTENT

CLAUSE NO.	DESCRIPTION
1.00.00	SCOPE OF WORK
2.00.00	SCOPE OF SUPPLY
3.00.00	GENERAL REQUIREMENTS
4.00.00	DESIGN CRITERIA
5.00.00	SPECIFIC REQUIREMENTS - SUPPLY
6.00.00	METHODS AND WORKMANSHIP
7.00.00	INSTALLATION
8.00.00	TESTS
9.00.00	DRAWINGS, DATA & MANUALS

ATTACHMENTS

ANNEXURE-A	NOTES AND DETAILS FOR CABLING SYSTEM
ANNEXURE-B	NOTES AND DETAILS FOR GROUNDING AND LIGHTNING PROTECTION SYSTEM

SECTION-IX

TECHNICAL SPECIFICATION FOR ERECTION - CABLING, GROUNDING AND LIGHTNING PROTECTION SYSTEM

1.00.00 SCOPE OF WORK

1.01.00 The scope of work covers complete and efficient design, supply, erection, testing and commissioning of Plant lightning protection system, all cabling and electrical grounding works. The scope shall broadly cover, but not be limited to :

1. Main Power House Building
2. Boiler area, ESP stack
3. Transformer yard
4. All auxiliary buildings (including electrical rooms of respective buildings) and structures as detailed in the Lead Specification.
5. Overhead interplant cable trestle and pipe cum cable trestle.
6. All electrical equipment as described in Volumes V-A & V-B.
7. 400kV Switchyard.

1.02.00 The scope of work shall also include all civil and structural works necessary for successful installation and commercial operation of all electrical equipment to be erected under this specification.

2.00.00 SCOPE OF SUPPLY

2.01.00 The scope of supply shall include but not be limited to the followings

2.01.01 Timely procurement and transportation to site in properly packed condition of all materials and miscellaneous items required to complete the erection work under this specification.

These materials and miscellaneous items shall include but not be limited to the following :

a) Galvanised steel pre-fabricated cable trays, coupler plates, nuts, bolts & washers, reducers, covers, wall brackets, hanger clamps, straight run, elbows, bends, etc.

b) Galvanised steel rigid/flexible conduits and accessories, ferrules, lugs, glands, terminal blocks, galvanised sheet steel junction boxes, cable fixing clamps, nuts & bolts, etc. as required.

c) Cable termination and jointing kits as necessary.

d) All necessary erection materials, consumables and sundry items including arc welding rods to complete the installation for satisfactory and trouble free operation.

e) Mild steel rods, galvanised steel flats, galvanised steel rods, lead coated copper tube suitably brazed with galvanised steel Bend ring galvanised steel wires, etc. required for grounding and lightning protection system shall be supplied in standard lengths.

f) Fire Stop mortal seal, fire retardant cable coating system.

g) Any item of works or erection materials which have not been specifically mentioned but are necessary to complete the work involved shall be deemed to be included in the scope of this specification and shall be furnished by the contractor without any extra charge to the Purchaser.

2.01.02 a) Main Ground Mat

Laying underground conductors and arc welding the conductors at each crossing and straight run (lap joint). Bidder shall select the diameter of conductor for the underground mat with supporting calculation. Suitable pigtails shall be provided.

b) Grounding Electrode

Ground electrodes will be 3 metre long, 40mm dia. M.S. rod. These are to be fabricated and driven into the ground by the side of mat conductor. All connections to the conductors shall be done by are wilding process.

c) Column Grounding

i) Concrete Columns

Erection of 1 no. M.S. rod (of diameter identical to ground mat conductor) from grounding mat to all concrete columns including necessary fixing, welding of one end of the rod with ground mat and the other end with the column above ground by welding with a short GS flat to edge angles.

ii) Steel Columns

Erection and connection of 1 no. M.S. rod (of diameter identical to ground mat conductor) from grounding mat to all steel columns including necessary fixing, welding of one end with ground mat and the other end with the column above ground with a short GS flat.

d) Risers

Erection and connection of all risers from underground mat to above ground levels where the ends will be left free for connecting to the equipment. Connection to the ground mat shall be done by arc welding and the other end is to be kept free at least 300 mm above grade level/concrete floor level unless otherwise shown.

e) Electronic Equipment Grounding

Internal ground connection of electronic panels shall be insulated from the enclosure, frame, chasis and to be terminated to an insulated ground bus.

Insulated ground bus (400x100x10mm) of all electronic panels shall be connected by insulated wire to an insulated common electronic ground bar as shown in the Grounding Notes and details drawing.

All connection made above shall be in the form of a radial distribution system without any parallel ground paths.

Electronic equipments and systems, metal enclosures of all electronic panels shall be connected to a grounding system with which is isolated and separate from the electrical equipment grounding system. Separate Earth pit shall be made of 3M X 3M (diameter to be selected by Bidder).

f) All other ancillary works in connection with the items of work described above which are not specifically mentioned but are necessary to complete the work, shall be under the scope of this specification.

2.01.03 a) Air Terminal

Installation of vertical 20mm dia galvanised steel rod (except for chimney). The projected length of the rod shall be as required to protect the object. (on which the rod is fixed from lightning stroke).

Installation of air terminal at the top of the stack/chimney for lightning protection shall be 20mm dia coated solid copper rod.

b) Horizontal Air Terminal

Erection of horizontal air terminal of 75X 10 mm GS flat conductor in such a way that no part of of the roof will be more than nine meters from the nearest roof conductor.

c) Down conductor

Erection of down conductor 75 X 10 mm GS Flat and 25 X 6 mm GS flat (Conveyor Gallery) conductor. one end of this down conductor connected with air terminal rod/ horizontal conductor at the top of roof/structure and other end connected to the nearest MS rod riser through test link located at approximately 1500mm above ground level.

d) Electrode (for Lightning protection)

Fabrication and driving into ground 3000 mm long, 40mm dia. M.S. rod and connecting them to the grounding mat by arc welding.

e) Risers (for Lightning protection)

Erection and connection of all risers from underground mat to above ground levels where the ends will be left free for connecting to the equipment. Each riser will be projected minimum 300 mm above grade level/concrete floor level. Riser will be of M.S. rod with diameter identical to ground mat conductor.

f) Shielding Mast

Erection of shielding mast at the top of steel columns cap plates of power house building.

g) All other ancillary works in connection with the items of work described above which are not specifically mentioned but are necessary to complete the work, shall be under the scope of this specification.

2.02.00 All materials and accessories to be supplied by the Bidder shall be brand new ones of reputed make.

2.03.00 Necessary drawings, data sheets and Technical leaflets on each piece of material.

2.04.00 **Scope of Services**

The scope includes but is not limited to the followings;

2.04.01 Furnishing of all erection tools and tackles, testing equipment, implements, supplies, hardware and transport for timely and efficient execution of the erection work.

2.04.02 The items of erection work shall be performed with respect to the following equipment/materials :

a) Power Cables

b) Cables laid in trench

c) Control, instrument and special cables

d) Supply and erection of entire cable tray and cable shaft arrangements indoor as well as outdoor area and all associated civil and structural works including foundation and cable trenches for complete plant.

e) Supply and Erection of Grounding system.

f) Supply and Erection of Lightning Protection system.

3.00.00 **GENERAL REQUIREMENTS**

3.01.00 **Codes and Standards**

3.01.01 All cable and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) and IEC except where modified and/or supplemented by this specification.

3.01.02 Cable and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

3.01.03 The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

3.02.00 **Erection Schedule**

3.02.01 The entire erection work shall be carried out in a phased manner. A schedule of the work showing the sequence of erection shall be submitted by the tenderer for this purpose.

3.02.02 The erection schedule, as approved by the Owner's Engineer shall be strictly followed by the contractor. If, for any reason beyond the control of the Contractor, the work is held-up then the Contractor shall bring it to the notice of the Owner's Engineer without any delay.

4.00.00 **DESIGN CRITERIA**

4.01.00 **Grounding System**

4.01.01 Grounding shall follow the relevant standards/codes amended till date as below:

a) Indian Electricity rules

b) National Electrical Code

c) Code of Practice of Earthing IS 3043

d) Protection of building and allied structures against lightning IS 2309

e) IS- 732, IS 226, IS 2629, IS 2633 & IS 4759

f) IEEE -80-2000, IEEE-665

The station grounding system shall be an interconnected network of MS conductor and MS ground rods. The system shall be provided to protect plant personnel and equipment from the hazards, which can occur during power system faults and lightning strikes

4.01.02 The main objectives of grounding system are to :

a) Provide safety to personnel from contact of dangerous potential caused by ground fault.

b) Ensure sufficient grounding current for effective relaying.

c) Stabilize circuit potential with respect to ground.

Design Basis

The station grounding system shall be designed in compliance with the IEEE-80-2000/ IEEE- 665 considering fault current of 50kA for 1 sec. and shall be subject to approval of Owner.

Actual soil resistivity measurement shall be carried out at proposed site for new units during dry season.

The surface resistivity shall be considered as 3000-ohm meter for Gravel and 1000 ohm-meter for concrete.

a) Major items of equipment, such as generator, switchgear, transformer, motor, relay panels and control panels etc shall have integral ground buses or connection points which shall be connected to the under ground grid.

b) Electronic panels and equipment, where required, shall be grounded utilizing an insulated ground wire connected in accordance with the manufacturer's recommendations. Where practical, electronics ground loops shall be avoided. Where this is not practical, isolation transformers shall be furnished. All indoor and outdoor electrical equipment and associated non current carrying system, metal works, support structures, buildings columns, fence, neutrals, masts, arrestors, etc shall be connected to the plant ground system.

c) Instrumentation cable screens shall be single point bonded to the instrument earth network to minimize the effects of electrical interference.

d) For Signal/case/intrinsically safe signal, grounding of control room instruments, separate earth pit not connected to main ground grid shall be used. Control cabinets shall be connected to this separate earth pit.

e) A grounding conductor (steel wire armor) shall be routed parallel to all power conductors operating above 240 volts.

f) All ground wires installed in conduits shall be un-insulated.

g) Embedded grounding grid of 75x10mm GI flat at basement/grade slab as well as upper floor/suspended slabs shall be provided.

h) In addition mild steel ground pads at different locations i.e. on wall/floor/ceiling inside the buildings/tunnels/trenches shall be provided. These pads will be in turn connected to below ground level earth mat through galvanized steel flat or riser. Each ground pad shall have provision for connection of at least two 75x10mm GI flats.

i) Treated earth pit shall be provided for system earthing at locations where generator and transformer neutrals are grounded. Two separate earthing leads shall be provided for each of the transformer and generator neutrals and shall be directly connected to a separate treated earth pit which in turn shall be connected to two different runs of earth grid. Heavy duty 50mm G.I. pipe shall be provide for treated earth pits with charcoal, salt, etc. as per IS:3043.

j) Dedicated treated earth pit shall be provided for lightning protection system.

k) Clean earthing for instrumentation shall be provided with dedicated earthing system and separate treated earth pits below the main control room, feed water pump house in turbine house etc.

l) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.

4.01.03 In order to meet the above objectives, ground grid mesh will be provided for the main plant complex, viz., switchyard, transformer yard adjacent to power house building, power house building and boiler area up to stack, auxiliary buildings, etc. The earth mats of main plant and BOP area will be interconnected by two or more connections.

All electrical equipment, non current carrying metal parts, structures, building steel, lightning protection system, generator/transformer neutrals will be connected to this station ground grid.

The major aspects to be considered for grounding system design are given below :

4.01.04 Ground Grid Conductor

a) Ground grid conductor of mild steel rod shall be used.

b) The minimum conductor section is determined on the basis of ground fault current. This section is then increased by an allowance to account for the soil corrosion loss of 0.3 mm per year over the design life of 30 years.

4.01.05 Underground Grid

a) The ground grid mesh is designed to keep the touch and step voltages within safe limits as per recommendation of IEEE 80 & IEEE 665.

b) The ground grid conductors will be buried in earth at a minimum depth of 1000 mm. The length of ground conductors below earth will be sufficient to ensure a ground resistance less than 0.5 ohm.

c) The ground grid conductor will be so laid as to provide short and direct connection to building steel and major electrical equipment.

d) Ground rods shall be provided at the points where system neutrals/lightning protections are connected to the ground grid.

e) All ground grid conductor connections will be welded type.

f) Main Plant ground grid shall be connected with the switchyard and other auxiliary building /area ground grid at least at two (2) points.

g) For test pits, the Electrode will be 100 mm dia. Heavy duty C.I. pipe with perforations. Electrodes installed in test pits will have disconnecting facilities

4.01.06 Above Ground Connections

a) Galvanised steel flats shall be used for all connections above earth.

b) Inside building, ground conductors will be run for each floor supported on building steel and/or cable trays. These ground conductors in turn will be connected to the station ground grid through riser (at least two) coming up along building columns/cable shafts.

c) Two separate and distinct ground connections will be provided for each electrical equipment in compliance with I.E. Rules.

d) All connections above ground will be welded type except connection to equipment/structures which shall be bolted type.

4.01.07 Equipment Ground Lead

Equipment ground connections will be sized to carry the available ground fault current. Considerations shall also be given to mechanical ruggedness of the connections and to limit the number of sizes.

4.01.08 The minimum ground conductor sizes for various equipment and structures are given in Annexure-B.

4.01.09 Entire erection of grounding work shall be carried out in such a way as to be capable of withstanding the intended services of carrying full short circuit level currents to ground mat without any damage/deformation.

4.02.00 **Lightning Protection System**

Lighting protection system design shall be as per IS:2309

4.02.01 The main purposes of lightning protection system are to :

a) Provide protection to structures from lightning strokes.

b) Provide a low resistance-conducting path to lightning discharge.

4.02.02 Lightning protection shall be provided for Power House building, auxiliary building , chimney, cooling tower and other structures.

4.02.03 Lightning protection will also be provided for building/ structures where the overall rise factor exceeds 10^{-6} as per IS:2309.

4.02.04 For metal structures which are electrically continuous down to the ground level, no lightning protection is required except adequate grounding connections.

4.02.05 System Design

a) Air termination network with down conductors and earthing electrodes will be provided on the basis of IS Code of Practice.

b) Horizontal air termination shall be so laid out that no part of the roof will be more than 9 meters from the nearest conductor.

c) Shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 Degrees.

d) Down conductors will run along the outer surfaces of the building and shall have a test joint about 1500 mm above ground.

e) An earth electrode will be provided at the connection point of the down conductor with the station ground.

f) Galvanised steel rods and flats will be generally used for air termination and connections. All connections will be welded type.

g) For air terminals of chimney, lead coated copper tube suitably brazed with G.S. Band ring shall be provided.

4.03.00 **Cabling System**

4.03.01 Erection of cabling work shall be carried out in such a way as to provide a reliable and assured electric power supply system to all station auxiliaries.

4.03.02 Cable routing will be done on unit basis as far as possible.

4.03.03 Erection of cabling work shall be executed keeping in view all necessities and requirements of fire fighting codes for Generating Stations having an adverse industrial environment.

4.03.04 Suitable embedded steel inserts shall be provided on wall/floor/ ceiling surfaces for welding of cable tray bracket in order to make the cable tray system withstand horizontal/vertical accelerations due to seismic forces for indoor trays and also wind load for outdoor trays such as on Boiler platforms in addition to normal tray cable loadings.

4.04.00 All erection work to be carried out under this specification shall conform to the notes and details given in Annexure-A and drawings attached to this specification.

5.00.00 **SPECIFIC REQUIREMENTS - SUPPLY**

5.01.00 **Equipment and Material**

5.01.01 Equipment and material shall comply with description, rating, type and size as detailed in this specification, drawings and annexures.

5.01.02 Equipment and materials furnished shall be complete and operative in all details.

5.01.03 All accessories, fittings, supports, hangers, anchor bolts etc. which form part of the equipment or which are necessary for safe and satisfactory installation and operation of the equipment shall be furnished.

5.01.04 All parts shall be made accurately to standard gauges so as to facilitate replacement and repair. All corresponding parts of similar equipment shall be interchangeable.

5.02.00 **Pre-fabricated Cable Trays**

5.02.01 Cable trays shall be pre-fabricated ladder type sheet steel with hot dip galvanising furnished in standard length of 2.5 metres.

5.02.02 Cable trays shall be of standard width specified in Annexure-A and drawings.

5.02.03 Cable trays shall be complete with all necessary hot dip galvanised sheet steel accessories such as coupler plates, ground continuity connections and associated nuts, bolts, washers, hangers, clamps, etc. Also horizontal / vertical bends, horizontal / vertical Tee, Reducers, Horizontal cross-pieces, protective covers shall be supplied along with straight runs in order to take care of cable tray alignments in different routes.

5.02.04 All fittings like horizontal/ vertical elbow, horizontal crosspiece, reducer, horizontal tee, etc. should be pre-fabricated. Each fitting shall be provided with two nos. hot dip galvanised side coupler plates & associated bolts, nuts and washers on each side.

5.02.05 Cable trays, fittings & accessories as well as elbows, reducers, tees, crosses, etc. shall be fabricated out of 14 gauge (2 mm thick) hot rolled mild steel sheets.

5.02.06 Contractor shall supply 14 gauge (2 mm thick) perforated type hot rolled mild steel sheet covers for vertical cable shafts up to a height of 2.5 metres from floor level. The perforated covers used for the vertical raceways may be of one or more pieces along the width of the raceway, depending on the width of the raceway and shall be bolted to the structural framework of the raceway.

5.02.07 The cable trays, fittings and accessories including all bolts, nuts, screws, washers, etc. shall be hot dip galvanised after fabrication as per IS:2629. Galvanising shall be uniform, clear, smooth and free from acid spots. Should the galvanising of the samples be found defective, the entire batch of steel will have to be re-galvanised at Contractor's cost.

The amount of zinc deposited shall not be less than 610 gms per square metre of surface area and in addition the thickness of the zinc deposit at any spot whatsoever, shall not be less than 75 microns. The Owner reserves the right to measure the thickness of zinc deposit by Elcometer or any other instrument and reject any component, which shows thickness of zinc at any location to be less than 75 microns.

5.02.08 The Contractor shall perform all tests necessary to ensure that the material and workmanship conform to the relevant standards and that such tests are adequate to demonstrate that the equipment will comply with the requirement of this specification.

The tolerance on dimensions shall be in accordance with appropriate Indian Standards. The extent of the tests to be performed by the contractor shall include but not be limited to the following:

Deflection Test

A 2.5 metre straight section of each type of cable trays shall be simply supported at the two ends. A uniformly distributed load of 100 Kg per metre will be applied along the length of the tray. The maximum deflection at mid span shall not exceed 7 mm.

5.02.09 For other details refer CABLING NOTES AND DETAILS annexed to this specification.

5.03.00 **Conduits and Accessories**

5.03.01 Conduits shall be of rigid steel, hot-dip galvanised, furnished in standard length of 5 metres, threaded at both ends.

5.03.02 Conduits diameter upto and including 25mm size shall be of 16 SWG and conduits above 25 mm diameter shall be of 14 SWG. Minimum diameter of conduits shall be 20 mm.

5.03.03 Each piece of conduit shall be straight, free from blister and other defects, internal surface shall be of smooth finish and covered with capped bushings at both ends.

5.03.04 The contractor shall provide and install all rigid steel conduits, mild steel pipes, flexible conduits rigid PVC pipes, etc. complete with accessories such as tees, bends, adopters, locknuts, pull boxes, conduit plugs, caps, etc as required for the cabling work.

5.03.05 Steel conduits with interior coating of silicon epoxy ester for ease of wire/cable pulling shall be seamed by welding and flo-coat metal conduit/hot-dip galvanised. These shall be supplied in standard length of 5M with minimum wall thickness as specified in IS:9537. In chemical handling areas, Battery Room, etc., the exterior surface shall be further coated with chromate and polymer for better resistance to corrosion. Conduits, fittings & accessories shall have ISI mark.

5.03.06 For sizes above 63 mm mild steel pipes with necessary fittings & accessories shall be provided and installed by the contractor. Pipes shall be manufactured by electric welding process. These pipes shall be of heavy duty class as per IS:1239 and shall have ISI mark. Pipes shall be supplied in lengths of approximately 5 metres. Pipes, fittings & accessories shall be hot dip galvanised both on inside and outside.

5.03.07 Flexible conduits shall comply with IS:3480. They shall be made with bright, cold-rolled, annealed and electro-galvanised mild steel strips. Flexible conduits shall be used between embedded conduits/pipes and the motor terminals. Flexible conduits shall also be used between fixed conduit and any equipment terminal boxes where vibration is anticipated or equipment that require regular removal.

5.03.08 Rigid PVC conduits conforming to IS:4985 shall generally be used for control & instrumentation cables in some areas where cable trays do not exist and where the runs are straight ones generally the PVC pipes with special Bell Mouthing shall be of 110 mm,160 mm & 200 mm outside diameter and shall be suitable for working pressure of 6 kg/sq. cm. The length of each pipe shall be 5 to 6 metres. Necessary fittings & accessories as may be required for the installation shall also be provided.

5.04.00 **Junction Boxes**

5.04.01 Glass Fibre Reinforced Junction Boxes

a) No. of Ways:12 / 24 / 36 / 48 with 20% spare terminals.

b) Design

Junction boxes shall be Glass Fibre Reinforced with saturated polyester informing to standards like DIN 16911 type 803 / 16913 type 834, 5 self extinguishing in accordance with ASTM D 635 / UL 94 VO.

c) Enclosure

Junction boxes for use in outdoor or damp locations shall be sturdy construction. Temperature resistance between – 10 to 100 deg C. Impact resistance shall be greater than 7 Nm, (EN 50 014). Protective insulation shall be in line with VDE 0100, dielectric strength shall be greater than 10 KV/ mm, halogen free toxicity, the enclosure and door cover shall be painted and electro-statically powder coated (preferably in RAL 7032). Earth connection (studs size shall be M6) shall be provided on the cover as well as door.

d) Doors

With integrated viewing window of 3 mm resistant plexi – glass or equivalent. The doors shall have industrial heavy – duty hinges. The doors shall be easily but firmly lockable with quick release fastener.

e) Protection Class :

Protection Category shall be IP 66 to EN60 529. There shall be guaranteed perfect seal to meet Protection class IP 66 providing sealing arrangement like highly elastic foamed in special type seal like polyurethane / chloroprene. The sealing rubber shall not have aging effect and shall retain its sealing characteristics for more than 20 yrs. Bidder shall indicate this in data sheet. The rubber seal should be pasted at its place with pasting technology for like more than 20 yrs (double sealing arrangement is preferred).

f) Mounting clamps and accessories :

Suitable for mounting on walls, columns and structure. Brackets, bolts, nuts, screws, glands and lugs required for erection shall be of brass. The accessories like mounting plants etc. of steel shall be powdered coated. The support rails for terminal box shall be zinc coated.

g) General :

i) JBs shall have small canopy at the top.

ii) There shall be rainwater collection arrangement from top and side of the outer ages to ensure that any leakage in to the junction box shall be avoided and it shall fall outside.

iii) Cable entry shall be from bottom side only.

iv) Ensure gland plate sealing perfect. It shall be of the same quality and arrangement as that of door to cover arrangement.

5.04.02 Steel Junction Boxes :

a) No. of Ways:12 / 24 / 36 / 48 with 20% spare terminals.

b) Design :

Junction boxes shall be designed in accordance with NEC, article 370, paragraph 18, 20 or equivalent standards.

c) Enclosure :

Junction boxes for use in outdoor or damp locations shall be sturdy steel construction. The enclosure and door cover shall be surface finished clean, degreased, phosphated, deep coated primed (preferably in RAL 7044) and electro-statically powder coated (preferably in RAL 7032). Earth connection (studs size shall be M 6) shall be provided on the cover as well as door. The sheath steel thickness shall be minimum 2 mm.

d) Doors :

The doors shall be hinged and lockable. The doors shall have industrial heavy – duty hinges. The doors shall be easily but firmly lockable with quick release fastener.

e) Protection Class :

Protection Category shall be IP 66 to EN60 529 / 10.91 complies with NEMA 4. There shall be guaranteed perfect seal to meet Protection class IP 66 providing sealing arrangement like highly elastic foamed in special type seal like polyurethane. There shall be an arrangement like multifold protection channel for additional stability and prevention of ingress of dust and water when the enclosure is open.

The sealing rubber shall not have aging effect and shall retain its sealing characteristics for more than 20 yrs. Bidder shall indicate this in data sheet. The rubber seal should be pasted at its place with pasting technology for like more than 20 yrs (double sealing arrangement is preferred).

f) Mounting clamps and accessories:

Suitable for mounting on walls, columns and structure. Brackets, bolts, nuts, screws, glands and lugs required

5.04.03 The junction boxes shall have the following indelible marking

- Circuit nos. on top by white-stenciled paint at site.
- Circuit nos. with ferrules (inside) as per approved drawing.
- Danger sign in case of 415V circuit.

5.05.00 **Terminals**

5.05.01 Multiway terminal blocks of approved type, complete with screws, nuts; washers and marking strips shall be furnished for connection of incoming/outgoing wires.

5.05.02 Each control cable terminal shall be suitable for connection of 2 nos. 2.5 sq.mm. stranded copper conductors without any damage to the conductor or looseness of conductors.

5.06.00 **Cable Termination & Jointing Kits**

5.06.01 The Bidder shall supply cable termination and jointing kits in requisite quantity for H.T. Power Cables, L.T. Power, Control Cables, Instrumentation Cables, etc. along with all accessories & consumables required for making termination and joints complete. All the materials and components of the termination/joints shall be suitable and compatible with the type of cables for which the terminals/ joints are intended.

5.06.02 The straight through joints of H.T. and L.T. cables shall be of Tapex/ Paracast/Parawrap type/approved make.. The end termination kits for H.T. cables shall be of Raychem/3M/Elastimold type/approved make. Cable joint or end terminations on Electrical equipment shall be suitable for Indoor & Outdoor use, as the case may be.

5.06.03 Glands and lugs required for termination of H.T., L.T. and instrumentation cables shall be supplied by the Contractor in required quantity.

5.07.00 **Cable Glands**

Cable glands shall be tinned brass gland, double compression type complete with necessary armour clamp and tapered washer, etc. Cable glands shall match with the sizes of different HT/LT/Control cables.

5.08.00 **Cable Lugs**

Cable lugs shall be suitable for termination of different cross-sections of H.T./L.T./Control/Instrumentation cables and shall be of following types :

i) Aluminium tubular terminal end for solderless crimping to aluminium conductors.

ii) Copper tubular terminal end for solderless crimping to copper conductors.

Solderless crimping of terminals shall be done by using corrosion inhibiting compound. The cable lugs shall suit the type of terminals provided on the equipment. Lugs for control/instrumentation cables shall be PVC insulated/sleeved type.

iii) Cable lugs for control cable termination shall be insulated. These lugs shall be pin type/flat type/ring type/U type to suit the terminals provided in the panels.

5.09.00 **Consumables and Hardware**

5.09.01 The Contractor shall furnish all erection materials, hardware and consumables required to complete the installation.

5.09.02 The materials shall include but not be limited to the following :

Consumables : Welding rods & gas, oil and grease, cleaning fluids, paints, electrical tape, soldering materials, etc.

Hardware : Bolts, nuts, washers, screws, brackets, supports, clamps, hangers, saddles, cleats, sills, shims, etc. 5.09.03 Supply of cement, sand, stone, etc. required for the execution of the contract shall be the responsibility of the Contractor.

5.10.00 **Testing Equipment**

5.10.01 The major testing equipment that are required to be provided by the Contractor are listed below :

a) Insulation Tests

i) Power operated Meggar - 1 KV and 10 KV grade

b) Hand driven earth Resistance Meggar, range 0-1/3/30 ohms.

c) High potential testing set - roller mounted type

d) Tong testers of suitable ranges.

e) Contact resistance measuring set for micro-ohms.

f) Torque wrench of various sizes.

g) Multimeters, test lamp, field telephone with buzzer set, different gauges, etc.

5.10.02 The list of equipment is indicative only. Any other test equipments required will be arranged by the Contractor.

6.00.00 **METHODS AND WORKMANSHIP**

6.01.00 All work shall be installed in a first class, neat workmanlike manner by mechanics/ electricians skilled in the trade involved.

6.02.00 The erection work shall be supervised by competent supervisors holding relevant supervisory license from the Government.

6.03.00 All details on installation shall be electrically and mechanically correct.

6.04.00 The installation shall be carried out in such a manner as to preserve access to other equipment installed.

7.00.00 **INSTALLATION**

7.01.01 Installation work shall be carried out in accordance with good engineering practices and also as per manufacturer's instructions/ recommendations where the same are available.

7.01.02 Equipment shall be installed in a neat workmanlike manner so that it is level, plumb, square and properly aligned and oriented.

7.01.03 Cable installation work shall mean erection of cable trays/racks, supports, hangers, junction boxes, conduits, laying of cables either in ground or on trays inside trenches tunnels/overhead trays in conduits, etc. dressing and clamping, jointing and termination inclusive of supply of necessary jointing/ termination kits, lugs, glands, ferrules, tapes, etc. and other accessories, grounding of cable armour. In case of direct laying in ground, all excavation work, necessary back-filling, supply of bricks and protective concrete slabs, removal of excess earth shall be part of the installation work.

7.01.04 Grounding installation work shall mean erection, jointing/ brazing/ welding, connection and painting, testing of ground conductors including supply of necessary steel/copper.

7.01.05 Lightning protection system installation work shall mean erection, jointing, welding, connection and painting, testing of air termination network, down conductors, shielding masts, connection to ground grid, electrodes, risers, horizontal conductors, etc. of lightning protection system.

7.02.00 **Cable Trays**

7.02.01 Pre-fabricated cable trays and accessories shall be assembled & erected at site. Adequate spaces will be provided to facilitate installation of cable system and to allow routine inspection and modification after installation.

7.02.02 Cable trays either inside concrete trenches or inside buildings and racks inside cable shafts shall be aligned and leveled properly. All tray runs shall be installed parallel to the trench/building walls and floors except otherwise noted in the approved drawings.

7.02.03 As far as practicable, cable trays shall be supported from one side only in order to facilitate installation and maintenance of cables from the other side.

7.02.04 The cable trays shall be supported in general at a span of exceeding 1.25 metres horizontally and 1.0 metre vertically.

7.02.05 Sufficient spacing not less than 250 mm shall be provided between trays and maintained to permit adequate access, for installing & maintaining the cables.

7.02.06 Complete cable tray support structure after installation shall be inspected/ tested for welding strength, straightness, accuracy, use of proper sizes and compliance to drawings.

7.02.07 Complete cable tray and accessory installation work shall be inspected/tested for proper alignment, leveling, use of proper accessories, high quality workmanship, etc.

7.02.08 The Contractor shall remove the RCC/steel trench covers whenever required and shall again place the same in their positions after the erection work in the particular area is completed or when further work is not likely to be taken up for some time.

7.02.09 Whenever any pipe/conduit/cable tray emerges out or enters into a building care should be taken to ensure that no water enters into the building.

7.02.10 Cable trays in areas subject to excessive coal dust, oil spillage, mechanical damage or accessible to personal contact shall be provided with raised sheet metal tray covers, installed on upper tray in horizontal run and front in vertical run.

7.02.11 Cable trays/racks shall be so arranged that they do not obstruct or impair clearances of passage way.

7.02.12 Cable tray/conduit system will be so designed as to accommodate maximum pulling tension and minimum bending radius of cable.

7.02.13 Cable tray/conduit system will be constructed to prevent drainage of water into equipment or building.

7.02.14 Cable tray/conduit system shall be electrically continuous and grounded.

7.02.15 Different voltage grade cables will be laid in separate trays when trays are run in tier formation. Power cables will normally be on top trays and control/instrumentation cable on bottom trays.

7.03.00 **Cable and Conduits**

7.03.01 The Contractor shall install, terminate and connect up all cable and conduits as per drawings and cable schedules.

7.03.02 The drawings shall be strictly followed except where obvious interference occurs. In such cases, the routing shall be changed as directed and/or approved by the Engineer.

7.03.03 Approximate lengths of cable and conduit runs will be shown by the contractor in the cable schedule for guidance only. Before commencement of work the Contractor shall take actual measurements and prepare his own cable-cutting schedule to reduce wastage to a minimum.

7.03.04 The Contractor shall also maintain and submit when requested, a record of cable insulation value when drawn from store, after laying, before and after termination/jointing.

7.03.05 Where direct heat radiation exists, heat isolating barriers, shall be adopted for cabling system.

7.03.06 Cabling/wiring in offices, laboratories, control rooms etc. shall be taken through concealed G.I. or rigid PVC pipes as directed by the owner's Engineer.

7.03.07 At certain places where hazardous fumes/gasses may cause fire to the cables, cable trenches after installation of cables shall be sand filled.

7.04.00 **Conduit and Accessories**

7.04.01 Conduit/pipes shall be used only in short lengths in certain areas where required and/or as directed by the Engineer.

7.04.02 The Contractor shall furnish all conduits complete with accessories as required.

7.04.03 Conduits shall be flexible type in general. However, rigid type steel conduit if required shall also be supplied by the Contractor.

7.04.04 Except for inside an enclosure wherever the cable enters or leaves the conduit, the conduit end shall be sealed by suitable sealing compound, having fire withstand capability.

7.04.05 The entire metallic conduit system, when embedded or exposed shall be electrically continuous and grounded.

7.04.06 Where it is possible for water or other liquids to enter conduits, sloping of conduit runs and drainage of flow points shall be considered.

7.04.07 Pull boxes will be installed between termination points where required to facilitate cable pulling, but at a maximum interval of 30 meters.

7.04.08 Conduits shall be firmly fastened within 900 mm of each junction box/pull box/cabinet/fitting, etc. Conduits shall be supported at least every 2000 mm.

7.05.00 **Cables : Storage and Handling**

7.05.01 Cable drums shall be stored on hard and well-drained surface so that they may not sink. In no case shall the drum be stored on the flat, i.e., with flange horizontal.

7.05.02 Rolling of drums shall be avoided as far as practicable, for short distance, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum.

7.05.03 In absence of any indication, the drums may be rolled in the same direction as it was rolled during taking up the cable.

7.05.04 For unreeling the cable, the drum shall be mounted on jacks or on cable wheel. The spindle shall be strong enough to carry the weight without bending.

7.05.05 The drum shall be rolled on the spindle slowly so that the cable should come out over the drum and not below the drum.

7.05.06 While laying cable, cable rollers shall be used at an interval of 2000 mm. The cables shall be pushed over the roller by a gang of people positioned in between rollers over a suitable distance. Care shall be taken so that kinks and twists or any mechanical damage does not occur in cables. Only approved cable pulling grips or other devices shall be used. Cables shall not be dragged on ground or along structure while laying out from cable drums.

7.05.07 Cable shall not be pulled from the end without having intermediate pushing arrangement. Bending radius of the cable during installation shall not be less than what is specified by the manufacturer.

7.05.08 Empty cable drums shall be returned to the Owner.

7.06.00 **Cable Laying**

7.06.01 Cables will generally be laid on ladder type prefabricated cable trays, cable rack, overhead supported from building steel/structures or cable bridge/cable trestle as per approved drawing. For outdoor area cable rack shall be used in Pipe Bridge for outdoor area cable interconnection. Cables shall be run in concrete trenches in transformer yard and switchyard only and in those electrical rooms at ground level, which are without any spreader room below. Cables buried directly in ground are not acceptable except for street lighting cable.

In indoor pumps, mechanical equipment areas overhead cable trays shall generally be used.

A.C. and D.C. circuit will not be run in same cable. Further, separately fused circuit will run in separate cables. Cables for redundant equipment system shall be run in separate trays, as far as possible.

7.06.02 Cables laid on trays and risers shall be neatly dressed and clamped with self-locking type fire resistant nylon ties at an interval of 750 mm. for horizontal and vertical runs, in case of both power, control and instrumentation cables.

7.06.03 All single core power cables for 3 Ph. AC circuits shall be laid in trefoil formation and suitably clamped with self-locking type fire resistant nylon ties at an interval of 750 mm.

7.06.04 All H.T. multicore power cables and L.T. multicore power cables with cross-sectional area including & above 95 sq.mm shall be clamped individually by self-locking type fire resistant nylon ties.

7.06.05 L.T. power cables of cross sectional area less than 95 sq. mm. and all control and Instrumentation cables shall be clamped in bunches with self-locking type fire resistant nylon ties. The number of cable in one bunch shall not exceed eight (8).

7.06.06 Prior to laying of cables inside the indoor and outdoor trenches, the contractor shall properly clean the trenches.

7.06.07 For underground crossing of railways, road, etc. additional protection shall be provided in form of hume pipe or concrete encased rigid steel conduits (duct bank.

7.06.08 After completion of installation and prior to connection, all power cables shall be subjected to a high potential test.

7.07.00 **Cable Tags & Markers**

7.07.01 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedules. Cables and conduits shall be tagged at their entrance, bends, every 30.0M and exit from any equipment, junction box. When a cable/conduit passes through a wall, tags shall be fitted on both sides of the wall.

7.07.02 The tags shall be of aluminium with the number punched on it and securely attached to the cable by not less than two turns of 16 SWG G.I. wire. For single core cable the wire shall be of non-magnetic material.

7.07.03 The location of cable joints, if any, shall be clearly indicated with cable marker with an additional inscription 'cable-joint'.

7.07.04 The Contractor shall furnish and install all tags and markers stated above.

7.08.00 **Cable Termination and Connection**

7.08.01 The termination and connection of cables shall be done strictly in accordance with manufacturer's instruction, drawings and/or as directed by the Engineer.

7.08.02 The work shall include all clamping, fitting, fixing, soldering, tapping, compound filling, cable jointing, crimping, shorting and grounding as required for the complete job. All equipment required for all such operations shall be of Contractor's procurement.

7.08.03 Furnishing of all consumable materials such as soldering material, electrical tape, sealing material as well as cable jointing kits shall be included in the offer.

7.08.04 Cable joint kits for all cables shall be supplied by Contractor under this specification. Responsibility for proper termination shall lie on the contractor. Guarantee for termination shall also have to be given by Contractor.

7.08.05 The equipment will be generally provided with blank bottom plates for cable/conduit entry and cable end box for power cables.

7.08.06 The Contractor shall perform all drilling, cutting on the blank plate and any minor modification work required to complete the job.

7.08.07 If the cable end box or terminal enclosure provided on the equipment is found unsuitable and requires major modification, the same shall be carried out by the contractor.

7.08.08 Control/instrumentation cable cores entering control panel/ switchgear/ MCC, etc. shall be neatly bunched and served with PVC perforated tape to keep it in position at the terminal block.

7.08.09 The Contractor shall put ferrules on all control cable cores in all junction boxes and at all terminations. The ferrules shall carry terminal numbers as per drawings. All ferrules shall be coloured, plastic & interlocked type.

7.08.10 Spare cores shall be similarly ferruled, crimped with lug and taped on the ends. Spare cores shall be ferruled with individual cable number.

7.08.11 Termination and connection shall be carried out in such a manner as to avoid strain on the terminals.

7.08.12 All cable entry Points shall be properly sealed and made vermin and dust proof. Unusual opening, if any, shall be effectively closed. Sealing work shall be carried out with approved sealing compound having fire withstand capability for at least three hours.

7.09.00 **Termi-point Connection**

a) The conductor (solid or stranded) is forced against the contact area of the 2.4 x 0.8 mm or 1.6 x 0.8 mm connection pin by means of a tin-coated bronze clip, which maintains a constant pressure. In the Maxitermi-point method, 2.4 x 0.8 mm pins is used without exception.

b) The conductor is "shot" onto the pin together with the clip. The resulting friction causes both the wire and the contact area of the pin to be cleaned and any oxide layers to be penetrated.

c) Apart from this the wire and the clip are deformed in such a way that a gas-tight connection with very good electrical and mechanical properties is established.

d) A special manually or pneumatically driven gun is required. Up to 3 adjacent connections can be "shot" onto one pin. In most cases only one clip at the base of the pin is attached. The sections above usually remain vacant. Any part of a connection pin may be reused several times after removal of the existing clip connection. Contact areas below existing connections that have become vacant can be reused by pushing the connections above the vacant space downwards, so that the new connection can be "shot" on above the top connection. The single jumper wires need not be specially prepared as the end insulation is stripped within the tool.

e) This connection method requires special insulation of the wires. The diameter of solid conductors is 0.8 mm the cross-section of stranded conductors 0.5 Sq.mm.

f) The conductor is deformed greatly when attached and is to be shortened by 3 mm when disconnected and reused.

g) Strips and special tools for termi-point connection shall be supplied by the Contractor.

7.10.00 **Cable Joints**

7.10.01 Cable shall be installed without joints as far as practicable.

7.10.02 If however jointing becomes necessary, it shall be made only by qualified cable jointer and strictly in accordance with manufacturer's recommendation.

7.11.00 **Grounding**

7.11.01 The Contractor shall carryout the interconnection among various peripheral earthing grids/mats, steel structures, lightning protection system as well as grounding of all electrical equipment, etc. The grounding work shall be carried out as per provisions of I.E. rules Indian standards and enclosed grounding and lightning protection notes and details.

7.11.02 The grounding shall be done by conductors of adequate sizes (size shall be selected by the bidder with supporting calculation) and the same shall be connected to the risers of main ground mat.

7.11.03 For fabricated cable trays, a separate ground conductor (50x6 mm G.S. flat) shall run along the entire length of each route of cable tray being suitably clamped on the cable tray. Individual cable trays of each section shall be connected to above ground conductor through 50x6 mm G.S. flat to maintain continuity of ground path.

7.11.04 All ground conductor connections shall be made by electric arc welding/ brazing unless otherwise specified. Ground connections shall be made from nearest available station ground grid risers. The rods/connection shall be coated with cold galvanizing /weather resistance anti corrosive paints.

7.11.05 All ground conductors shall be painted black for easy identification.

7.11.06 Equipment ground connections, after being checked and tested by the Engineer, shall be coated with anti-corrosive paint.

7.11.07 Whether specifically shown or not, all conduits, trays, cable armour and cable end box, electrical equipment such as motors, switchboards, panels, cabinets, junction boxes, lockout switches, fittings, fixtures, etc. shall be effectively grounded.

7.11.08 If there is no provision to ground the L.T. transformer neutral at transformer end, to make an effectively earthed 415V system the neutral bus of all 415V distribution boards shall be connected to ground grid at two different and distinct points.

7.11.09 The underground mat will be made of mild steel rods laid underground in length and breadth of the area at a depth of minimum 1 metre below grade level. All crossings and straight run shall be arc welded for good electrical continuity. Ground conductors, when crossing underground trenches, directly laid underground pipe and equipment foundation, if any, shall be at least 300

mm below the bottom elevation of such trenches/pipes as shown in the relevant drawing.

The Contractor will plan and organise works to lay the grounding mat in the same sequence in which the building and equipment foundation is being done.

7.12.00 **Painting**

7.12.01 The Contractor shall paint steel fabrications at site with two (2) coats of red oxide primer. Finish paint shall be as per TSGENCO standard practice which will be informed to Bidder during detail engineering. Also refer to clause no. 1.16.00 of Section-I, Volume V-A.

7.13.00 **Galvanising**

7.13.01 The galvanising shall be uniform, clean, smooth, continuous and free from acid spots. Should the galvanising of the samples be found defective, the entire batch of steel has to be regalvanised, at Contractor's cost. The amount of zinc deposit shall not be less than 610 grams per square metre of surface area and in addition, the thickness of the zinc deposit at any spot whatsoever shall not be less than 75 microns. The Owner reserves the right to measure the thickness of zinc deposit by Elkometer or any other instrument and reject any component which shows thickness of zinc at any location less than 75 microns.

7.14.00 **Excavation and Back Filling**

7.14.01 The Contractor shall perform all excavation and backfilling as required for buried cable and ground connections.

7.14.02 Excavation shall be performed up to the required depth. Such sheeting and shoring shall be done as may be necessary for protection of the work.

7.14.03 The Contractor shall make use of his own arrangements for pumping out any water that may be accumulated in the excavation.

7.14.04 All excavation shall be backfilled to the original level with good consolidation.

7.15.00 **Steel Fabrication**

7.15.01 All racks, trays, supports, hangers & brackets wherever necessary shall be fabricated by the Contractor.

7.15.02 Steel for fabrication shall be straightened and cleaned of rust and grease. All fabrication shall be free of sharp edge and burns so as not to cause any damage to personnel or cables.

7.16.00 **Cleaning up of Work Site**

7.16.01 The Contractor shall, from time to time, remove all rubbish resulting from execution of his work. No materials shall be stored or placed on passage or drive ways.

7.16.02 Upon completion of work, the Contractor shall remove all rubbish, tools, scaffoldings, temporary structures and surplus materials etc. to leave the premises clean and fit for use.

8.00.00 TESTS

8.01.00 Shop Tests

8.01.01 All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant Indian Standards at manufacturer's works.

8.01.02 Tests on panels/junction boxes shall include :

a) Wiring continuity tests.

b) High voltage and insulation tests.

c) Operational tests.

8.02.00 Site Tests

8.02.01 Contractor shall thoroughly test and meggar all cables, wires and equipment to prove the same are free from ground and short circuit.

8.02.02 If any ground or short circuit is found, the fault shall be rectified or the cable and/or equipment replaced.

8.02.03 All power cables after installation and prior to connections shall be subjected to High Potential tests. Also the insulation resistance values shall be measured both before and after Hipot test for comparison. The leakage current shall also be measured during the Hipot test at site.

Cable cores shall be tested for :

a) Physical damage

b) Continuity

c) Correctness of connections as per relevant wiring diagram

d) Insulation resistance to earth

e) Insulation resistance between conductors

f) Proper earth connections of cable glands, cable boxes, cable armour, screens etc.

8.02.04 All equipment shall be demonstrated to operate in accordance with the requirements of this specification.

8.03.00 Test Certificates

8.03.01 Type test certificate on any equipment, if so desired by the Owner, shall be furnished. Otherwise the equipment shall have to be type tested, free of charge, to prove the design.

9.00.00 DRAWINGS, DATA & MANUALS

9.01.00 To be submitted with the Bid

9.01.01 Make, type and catalogue number of different electrical items and accessories along with technical leaflets, data sheets etc.

9.01.02 Typical General arrangement drawings showing constructional features, fixing arrangement of pre-fabricated cable trays.

9.01.03 Bill of Materials for cable trays and accessories, conduits & accessories.

9.01.04 Layout of Grounding system & lightning protection system showing connection and other details along with backup design calculations and detailed write up.

9.01.05 Bill of materials for grounding and lightning protection system.

9.01.06 Drawing showing details of equipment grounding.

9.02.00 **To be submitted after Award of Contract**

9.02.01 Make, type & catalogue number of cable termination kits, joints & accessories.

9.02.02 Detail dimensional drawings showing constructional features, grounding, fixing arrangement etc.

9.02.03 Bill of Materials for Pre-fabricated cable tray and accessories, Conduits & accessories.

9.02.04 Dimensional G.A. drawings and data sheets for different equipment and items supplied under this specification.

9.02.05 Layout drawing of Grounding system and Lightning protection system showing connection details along with backup design calculation and detailed write up.

9.02.06 Bill of material for grounding system and lightning protection system.

9.02.07 Drawing showing details of equipment grounding system.

9.02.08 Cable schedule and inter-connection charts for the entire power plant.

ANNEXURE-A

NOTES AND DETAILS FOR CABLING SYSTEM

1.00.00 **GENERAL**

1.01.00 These notes and details shall be read and construed in conjunction with Specification and the drawings meant for cable tray details and supporting arrangements in Trench, Racks etc., enclosed elsewhere. In case of conflict between these notes and drawings, the latter shall prevail.

1.02.00 The Cabling System installation work shall conform to the requirements of the latest revisions of the following standards/codes

a) Indian Electricity Rules, 1956, with up to date amendment.

b) I.S. Code of Practice.

2.00.00 **CABLE ROUTING/LAYING**

2.01.01 Cables shall generally be laid on ladder type cable trays either in trenches or overhead supported from building steel/structures except in some cases cables may have to be laid underground and for short runs in conduits for protection or crossing.

2.01.02 For interplant connections, the cables may be directly buried or routed through an overhead cable bridge or cable trenches/tunnels selection being dependent on site constraints.

2.01.03 For underground crossing of railways, roads etc. hume pipes shall be used and shall be laid at a depth of minimum 1000 mm such that cables shall not be damaged.

2.01.04 In boiler area, trench will be avoided as far as practicable. The cable racks shall be supported from Boiler structure in vertical configuration with suitable cover to avoid deposition of coal dust as far as practicable.

2.01.05 Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. Power cables shall be on top trays and Control/Instrumentation cables on bottom trays, and it is recommended that trays for cables of different voltage levels be stacked in descending order with higher voltage level above.

2.01.06 Cables for redundant equipment/system shall be run in separate trays in separate route.

2.01.07 Cables from two different services viz. supply from station board and supply from unit board shall be fully segregated to prevent simultaneous damage due to fire in one of the services.

2.01.08 Low level signal cables and other special Instrumentation and Control cables shall run in separate trays. In general, a minimum of 1500 mm clearance shall be maintained between these cables and noise generating equipment (large motors, generators, transformers etc.).

2.01.09 The cable spreaders of each unit shall be compartmentalized by provision of fire proof partition wall.

2.01.10 The floor of the cable spreader rooms will have to be made water proof so that water does not percolate to lower levels in the event of fire fighting operations. Adequate arrangement for efficient drainage of water shall be provided. The cable raceways should also be suitably curved to avoid water entry through this place.

2.01.11 Cabling System for CHP

a) Cable in CHP area shall be generally routed through the conveyor gallery / tunnel, TP / Buildings by separate supporting structures, Pipe cum cable bridge. The cables shall be laid in vertical trays.

b) In substation & switchgear room cable shall be laid in horizontal cable trays installed in cable vault room.

c) Cables may also be routed through hume pipes to enter into various buildings from the nearest overhead cable trestle/substation building.

d) Overhead cable trestle/cable bridge shall be provided for routing of cables between the following Sub-Stations/buildings:

i) Main CHP Substation Building and Crusher House.

ii) Main CHP Substation Building and Pump House (if required).

iii) Wagon Tippler Substation Building and TP.

The bottom of the steel supporting structure shall be generally at 2.5m above the grade level except for road crossing and rail crossing where the same shall be 6.5 m and 9.0m respectively above grade level.

e) Cable trays shall be laid out horizontally in sub-station buildings and pump-house whereas the same shall be installed vertically inside transfer points, crusher house, conveyor gallery/tunnel etc. The cable trestle shall have a minimum 600mm clear walk way all along its routes and shall have maintenance platforms as required.

f) Separate trays shall be provided for H.T., L.T., control and instrumentation cables. LT mutlicore Power cables shall be laid in single layer & touching formation and single core cable in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil centre lines and clamped at every two meter while control and instrumentation cables shall be laid in maximum of two layers formation. Single core HT power cables shall be laid on trefoil formation with a distance of four times the diameter of cable between trefoil centre lines and clamped at every two meter and Multi core power cables shall be laid in single layer & touching formation. Normally cable trays shall be designed with 70% fill-in criteria and

conduit 40% fill-in criteria. Same cable laying philosophy shall be considered in other areas of the plant, if not specifically mentioned.

2.02.00 **Cable Trays/Supports**

2.02.01 Cable trays and covers shall be pre-fabricated type, constructed from minimum 14 SWG sheet steel for trays and 16 SWG for covers and hot-dip galvanized after fabrication.

2.02.02 Cable tray supports shall be cantilever type for each installation. All supports and hardware shall be hot-dip galvanised.

2.02.03 Standard cable tray width shall be 600 mm. However, trays with 450, and 300, 150 mm width may be used in some places considering the requirement and space restrictions. For instrumentation and control purpose, some perforated type cable trays of width 150 and/or 100mm may be used particularly in Boiler Platform area, and 600, 450, 300 mm perforated trays may be used depending on site requirement.

2.02.04 Cable trays shall be ladder type with 250 mm rung spacing, 100 mm depth and rung width not less than 50 mm. Ladder type trays for power & control cables and perforated type for instrumentation cables shall be provided.

2.02.05 All weld for cable tray supports shall have a min. throat thickness of 6 mm.

2.02.06 Cable trays in areas subjected to excessive coal dust, or mechanical damage will have hot-dip galvanised sheet metal tray cover installed on front tray in vertical run and inverted `V' type on upper tray in horizontal run.

Where covers are used on trays containing power cables, consideration should be given to ventilation requirements. Areas where corrosive chemicals are likely to be handled, cable tray and covers shall be epoxy painted.

2.03.00 **Conduits**

2.03.01 Conduits shall be rigid steel coated type; minimum size of conduit shall be limited to 19mm.

2.03.02 Steel conduits with interior coating of silicon epoxy ester for ease of wire pulling shall be seamed by welding and flo-coat metal conduit/hot-dip galvanised. These shall be supplied in standard length of 5M with minimum wall thickness as specified in IS:9537 Part-II. In chemical handling areas, Battery room etc., the exterior surface shall be further coated with chromate and polymer for better resistance to corrosion.

2.03.03 Conduit runs shall be supported at an interval of 750 mm for vertical run and 1000 mm for horizontal run.

2.03.04 Conduits shall be sized so that conduit fill (ratio of total cable area to conduit area) shall not exceed the following :

One Cable	:	53%
Two Cable	:	31%
Three Cables & Up	:	40%

2.03.05 Conduit runs shall be provided with necessary bends as required.

2.04.00 **Installation**

2.04.01 The Contractor shall install terminate and connect up all cables and conduits with supporting arrangements as per drawings, cable schedules and interconnection chart/drawings.

2.04.02 The HV power cables of 11 KV/3.3 KV shall be laid in trays or racks as follows :

a) In single layer only.

b) Multi core cables to be laid in touching with each other.

c) Single core cables to be laid in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil centerlines and clamp every two meter.

2.04.03 1100V grade power cables shall be laid in single layer in trays.

2.04.04 1100V grade mutlicore power cable shall be laid in touching formation to each other.

2.04.05 1100V grade Single core cables to be laid in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil centerlines and clamp every two meter.

2.04.05 Control and Instrumentation cables can be laid up to a maximum of two layers in each tray.

2.04.06 Normally cable trays shall be designed with 70% fill-in criteria and conduit 40% fill-in criteria. Same cable laying philosophy shall be considered in other areas of the plant, if not specifically mentioned.

2.04.07 The trays shall be run with a vertical spacing of 300 mm for overhead cable trays as well as inside cable trenches. A minimum of 225 mm clearance shall be provided between the top of tray and beams, cold piping, 500 mm clearance for hot piping/object to facilitate installation of cables in tray.

2.04.08 Adequate pull boxes shall be provided in conduit run to facilitate cable pulling in long runs and also to ensure that there will be no more than 270 Deg. bends between pull points.

2.04.09 Cable tray/conduit system shall be installed to accommodate cable manufacturer's recommended maximum pulling tension and minimum bending radius.

2.04.10 All openings in the floor and wall for cable access shall be sealed after installation of the cable system with non-inflammable materials, as follows :

i) Fire stop/Penetration seal shall be installed in the cable spreaders and cable raceways.

ii) Similarly in the trenches fire stop/penetration seals shall be provided at suitable interval to avoid spread of fire.

iii) For all H.T., L.T., Relay and Control panels, Control desk, instrumentation panels, battery charger, D.C. Dist. boards and other miscellaneous panels, fire-stops should be provided below base plate.

2.04.11 All floor/wall openings for cable entry to the electrical equipment and accessories shall be sealed with non-inflammable materials, after completion of cable installation. Thickness of such materials shall be equal to the thickness of floor/wall unless specified otherwise.

2.04.12 The portion of galvanised steel, which, if required, undergoes any welding at site shall be coated with two (2) coats of cold galvanising anti-corrosive paint after welding.

2.04.13 Refer Clause No. 3.00.00 below for details of fire-proof sealing and fire protection coating.

2.05.00 **Identification**

2.05.01 The complete cabling system shall be properly identified. Methods for identification of cabling system shall be furnished to the successful EPC Contractor shall strictly adhere to the said methods.

2.05.02 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.

2.05.03 Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanised iron plate, projected above ground level.

2.05.04 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, at each bend and at every thirty (30) metres in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, MCC, control & relay panels etc. wherever required for cable identification, such as where a number of cables enter together through a gland plate.

3.00.00 **FIRE-PROOF SEALING / FIRE PROTECTION COATING SYSTEM**

3.01.00 The Fire proof sealing / fire stop system / fire protection coating system is required to prevent spreading of fire from one placed to other place (or one zone to other zone) through the openings in wall / floor, cables laid in trays / racks and openings below Electrical Switchgear / MCC / Distribution boards / Cabinets / Panels, etc. The fire proof sealing system shall conform to the latest edition including amendments of BS-476.

3.02.00 **Scope of Work**

3.02.01 The scope of work includes but is not limited to the following supply and services:

i) Fire Stops in wall / floors.

ii) Fire stops below switchgear / MCC / Switchboards, junction boxes / panels / cabinets, etc. which are floor mounted type.

iii) Fire retardant coating to be applied for installed cables.

iv) Minor civil / structural works for installation of the entire work.

v) All necessary erection materials, consumables and sundry items to complete the entire work for satisfactory and trouble free operation.

vi) Any special tools & tackles.

vii) Conducting the type test of fire proof sealing system in presence of Owner's engineers.

viii) All relevant Drawings, Data sheets and instruction manuals.

ix) Fire proof barrier walls.

x) Fire proof doors.

3.03.00 **Design Criteria**

3.03.01 Fire Proof Sealing System

The material / components used for fire-proof sealing system shall be provided to meet the following requirements:

i) Life expectancy should not be less than 30 years from the date of installation.

ii) Free from shrinkage or cracking or asbestos in composition and should achieve smoke and gas tightness during fire and should be modifiable.

iii) Not to generate toxic gas and harms to the personnel handling the system.

iv) Prohibition of production of acid or alkali during gas generation.

v) Will not produce suffocating / corrosive gas.

vi) Repellant to paste / rodent / termite.

vii) Expansion co-efficient - very low which is to be comparable with masonry concrete.

viii) Not soluble / reactive to acid, water, alkali.

ix) Thermal conductivity - low.

x) The material in contact with the cables in the fire-proof sealing system shall be compatible with the material used for outer sheath of cables.

xi) It should not have any adverse effect on the cables and should not alter the current carrying capacity of the cables.

xii) Retrofit in design to accommodate not less than 15% more addition of cables depending upon the size of cables, physically and chemically stable.

xiii) Capable of withstanding vibrations, drop-loads, foot traffics, mechanical loads, etc.

xiv) The F.P.S. system shall maintain its integrity and perform satisfactory even after

a. Remaining in water for a long time.

b. Accelerated thermal aging.

c. Sustaining vibrations.

xv) The design and construction of F.P.S. system shall specifically take into account the fact that under seismic disturbances, normal load, short circuit and fire conditions, the cable / cable trays will be subject to movement, expansion and oscillation and this shall not result in any damage or cause dislocation of the F.P.S. system or the material constituting the FPS System.

xvi) Non-hygroscopic, non-inflammable and shall not get affected over a period of time due to humidity, moisture and ozone etc. and should not contain volatile solvents which may cause a fire hazard during application.

xvii) The fire rating shall not be less than one (1) hour and the system shall be stable after applicable of water jet in the exposed side in order to extinguish fire.

3.03.02 Fire Protection coating to be applied on installed Cables:

The cables shall be coated with fire protection material of 2 mm dry thickness at the strategic locations as follows so as to limit the spread of fire:

i) At fire stops in walls and floors on either side upto 500 mm length.

ii) At fire stop below Electrical Switchgears/ MCCs/ Panels/ Cabins, etc. on one side coating of 500 mm length, i.e., on the cable vault side / cable trench side.

iii) Length of 500 mm on all sides of the junction/crossing of cabling work in open cable routes/ cable trench.

iv) In fire risk areas and where specified at suitable intervals as decided upon side conditions in open cable routes.

v) Where necessary and specified at site intervals along cable routes in cable trenches.

vi) The coating shall be applied evenly on the cables only.

3.03.03 The fire protection coating shall have the following properties/composition:

i) Asbestos free, non-volatile, not eatable by vermin, harmless and non-irritant to skin of human.

ii) Not affecting the current carrying capacity of the cables and the properties of the installed cables.

iii) It shall delay fire damage to cables and prevent flame spreading meeting the requirement of IEEE - 383.

iv) Coating material shall show no signs of cracking and peeling when the coated cable is bent to the radius of minimum 12 times the diameter of the maximum size cable at 180°C.

v) The limiting oxygen index of the material shall not be less than 60% as per ASTMD - 2863.

vi) Life expectancy equivalent to the cable installations.

3.03.04 The various openings in the cable vault, vertical/ horizontal raceways of cables penetrating walls/ floors and the bottom of Electrical switchgears/ MCCs/ distribution boards/ Cabinets/ Panels shall be provided with fire stop systems. Cables passing through the openings at various locations are laid on various tiers of the cable trays/ racks in the bunch formation. Bidder shall visit the site to assess and get acquainted with the type of cable installation where fire stops and fire protection coating are to be provided. In case steel frames are required to be fabricated and fixed in the openings, the fabrication of frame & fixing of the same shall have to be done by the Contractor without any extra cost. The necessary steel section for fabrication of frames shall be supplied by the Contractor without any extra cost. Any civil works required to be done in the openings shall be carried out by the Bidder. Bidder shall also include one set of tools & accessories required for addition or removal of cables after the seal is made.

3.04.00 The bidder shall quote the unit rates for provision of supply, installation, testing & commissioning of the fire proof seals as given in the specification. Bidder is requested to quote the unit rates per square metre (i.e., area) basis of the area of the fire sealing material.

3.05.00 **Type Test On Penetration Seals**

3.05.01 The type tests for fire proof/ penetration seal for floor and wall opening/ fire stop system for bottom of electrical switchgear/ MCC/ panel base are as under:

i) Fire rating test.

ii) Hose Stream test.

iii) Accelerated aging test.

iv) Fire rating test on the penetration seal system built out of accelerated aged components followed by hose stream test.

v) Temp. rise test for cable in the fire stop.

vi) Water absorption test followed by fire rating test.

vii) Flame Resistance test for fire retardant coating material.

viii) Anti-rodent test.

3.05.02 Fire Rating Test

This test shall be carried out to prove the guaranteed power rating duration of the system in respect of stability, integrity and insulation characteristics of the complete system. The penetration seal system as a whole conforming to ASTM 814 and as per BS:476 Part-8 shall be built with the necessary component. The fire test shall be built with the necessary component.

The test specimen of the penetration seal built with 9-10 nos. armoured cables of various sizes passing through the seal shall be fitted to the gas fired furnace and shall form the upper most face of the furnace. The gas fired furnace shall have provision to achieve standard time temperature characteristics for fire tests as mentioned in BS-476 Part-8, according to which the temperature required to be maintained are as under:

Heating time in minutes	**Temperature in the furnace**
30 minutes	821°C
90 minutes	886°C
120 minutes	1029°C
150 minutes	1062°C
180 minutes	1090°C
210 minutes	1113°C
240 minutes	1133°C

The pressure inside the furnace at the time of test shall be more than 2 mm water gauge. The penetration shall be subjected to fire test with surface exposed to controlled fire in the furnace conforming to time / temperature characteristics as mentioned above. During the test, the temperature of both the faces of the penetration seal, i.e. one which is exposed to fire and the other unexposed, shall be measured by calibrated thermocouples after regular interval of 5 minutes. At least 3 thermocouples shall be provided for temperature measurement of each face.

3.05.03 The results at the end of the tests shall be interpreted or failure criteria as under:

i) The system is deemed to have failed to maintain stability if there is a total collapse of the penetration seal.

ii) In case cracks are seen on the face of the penetration seal or cracks through the sealing system through which the flame / or gas can pass,

the system is deemed to have failed to maintain integrity. The development of crack is characterized by ignition cotton wool held near the seal on the unexposed surface at a distance of about 30 mm from the aperture.

iii) In case the mean temperature rise of unexposed surface of seal exceeds 140°C above the initial temperature or temperature of unexposed surface exceeds 180°C, the system shall deemed to have failed in respect of insulation characteristics.

iv) Temperature measurement on the unexposed side of the penetration seal specimen shall be measured by the thermocouple on the surface of penetrating items and on fire stop material in accordance with ATME-814/UL 1479 at a distance of 25 mm from fire stop material and penetration items respectively.

3.05.04 Hose Stream Test:

The intention of the hose stream test is to ascertain whether the penetration seal assembly maintains its stability on application of water jet after withstanding the fire for 1 hour i.e. the guaranteed fire rating duration.

The test apparatus for this test shall be similar to the one used for carrying out the fire rating test. The penetration seal system shall be subjected to the action of hose stream at the nozzle pressure of 30 psi supplied for a duration of 1.5 sec./ sq.ft. of exposed area. The hose stream shall be applied with 1.1/ 8" dia. nozzle at a perpendicular distance of approximately 17 ft. from the centre of the assembly on a line approximately 270 deg. from the line normal to the centre for the test assembly. The water stream shall be applied within 4 minutes and 30 seconds after completion of fire rating test.

However, this period shall not exceed more than 10 minutes in case of practical difficulties experienced by testing stations. The application of water stream shall be maintained through out the test duration and shall traverse the complete fire stop system.

The fire stop assembly is deemed to have passed the hose stream test successfully if no through projection of water is noticed on the unexposed surface of the seal. Further on completion of hose stream test, the appearance of the penetration seal system shall not alter substantially indicating thereby that the stability of the system ahs been maintained.'

3.05.05 Accelerated aging test

The intention of accelerated aging test is to ascertain whether the artificial aging of the systems and components thereof results into change in the mechanical properties or in the form. In order to simulate aging, artificial aging shall be resorted to.

For the purpose of subjecting the penetrations seal system components to accelerated aging, the system / components shall be stored for 336 hours in air furnace where the temperature of the inside air, shall be maintained at 100 degree centigrade. However, for system components in pliable form, system component shall be stored for 448 hours in air furnace where temp. of air inside the furnace shall be maintained at 75°C. It is assumed that the

changes occurring during test period would roughly correspond to the effect on aging over a period of about 40 years.

After completion of 336 hours / 448 hours, the mechanical properties such as tensile strength element, elongation and hardness of the material (as may be applicable) shall be tested. These results shall be compared with corresponding values before subjecting to accelerated aging test.

The change in the form of system / components shall also be compared with the form before the tests to ascertain whether the system / components thereof have undergone any permanent change.

In case the mechanical properties before and after the accelerated aging do not indicate substantial change, the system shall be deemed to have passed the accelerated aging test. Similarly the variation in the form of the system components at the end of the test shall not indicate permanent deformation which is likely to affect the ceiling properties of the system.

3.05.06 Fire Rating test After Accelerated Aging:

Intention to this test is to ascertain whether the penetration seal built out of components already subjected to accelerated aging still passes the fire rating test for guaranteed fire rating duration.

The test apparatus for this test shall be similar to the one used for fire rating test mentioned above. The assembly or the penetration seal shall be carried out with the components which were subjected to accelerated aging test based on the test procedure mentioned above. In case there is a problem of co-ordination with the test station, the prototype assembly may be subjected to aging in manufacturer's works under the conditions mentioned above and live fire test should be carried out at manufacturer's works in presence of Owner's representative.

In live fire test, the temperature of fire shall be of the order of 1000 deg.C at the end of 3 hours. The test shall be carried out at atmospheric pressure.

The interpretation of test results for failure shall be similar to those mentioned under fire rating test/live fire test at (1) - (c) above.

3.05.07 Temperature rise test for cable in the fire stop:

This test shall be carried out to ascertain whether due to inadequate dissipation of heat at the location of fire stop, the temperature of cable conductor or outer sheath in contact with the fire stop, rises beyond the acceptable limits due to which whether any derating is required for cables.

Fire stop systems hall be erected with, at least 8-10 armoured cables, specially power cables. While laying the cable through penetration seal, thermocouple shall be placed on the outer surface of cable in contact with the fire stop system. The location shall be selected where there exists possibility of inadequate dissipation of heat from cables to the atmosphere due to fire stop components. Two thermocouples shall also be located on the two surfaces of the fire penetration seal system. Similarly thermocouples shall also be placed on the other surface of cables where there exists contact of free air without any obstruction so as to enable adequate nature cooling.

In case the temperature of outer surface of the cable in contact or inside the fire stop system does not exceed 75 degree centigrade, it is inferred that no derating of cable is required for cable when used in conjunction with the particular fire stop system.

Test shall be repeated with reduced current till the temperature of cable outer surface in contact with fire stop system is limited to 75°C. The rate of the current so guaranteed by the cable manufacturer as free air rating shall be the derating factor.

3.05.08 Water Absorption Test:

The test specimen shall be immersed in fresh clean water at a temp. of 20°C. The test specimen must be separated from the bottom and sides of the soak tank by at least 10 mm and it shall be covered by approximately 25 mm of water. At the end of the 24 hours soak period, the specimen shall be removed from the water and moped up with a damp cloth.

Fire rating test after water absorption is to ascertain whether the penetration seal subjected to water absorption still passes the fire rating test for guaranteed fire rating duration.

The test apparatus for this test shall be similar to the one used for fire rating test at Sr. No.1. In case there is problem of coordination with test stations, the prototype assembly may be subject to water absorption test at manufacturer's works followed by live fire test which should be carried out at manufacturer's works in presence of Owner's representative. In line fire test, the temp. of furnace shall be of the order of 1000°C at the end of 3 hours. The test shall be carried out at atmospheric pressure.

3.05.09 Flame Resistance Test for fire Retardant Coating Material:

Sample strips shall be of ½ " wide, 12" long and approximately 70 mills in thick (without any reinforcement). Each strip shall be held vertically (clamped at the top) in a natural gas burner flame, (blue cone of flame touching bottom edge of sample) for 10 minutes. The flame shall then be removed and observation shall be recorded. In case, any flaming of the samples should cease after the removal of gas burner. White charred length of the sample should not exceed 1 & ½".

3.05.10 Anti-Rodent Test:

Physical tests:

a) This test shall be carried out to ascertain the anti-rodent properties of the components of the Fire proof sealing system.

b) This test shall be carried out at approved test station performing sealing system tests on pharmaceutical products. The complete Fire Proof sealing system shall be subjected to attack of inspect / vermin such as rate for about 20 days.

c) At the end of the test condition of the surface of Fire Proof sealing system the test material shall be compared with the surface condition

before commencement of the test. The fire stop shall be deemed to have passed this test in case no marks of growth are seen on the surface.

3.05.11 Test Certificates

Certified copies of all tests carried out at works and at site shall be furnished in requisite number of copies.

Test reports shall be complete with all details and shall also contain limit valves specified in the relevant standards, wherever applicable, to facilitate review of Test Report/ Certificates.

The fire proof sealing system shall be installed only after receipt of approval of the test reports.

3.05.12 Testing Charges

The bidder has to indicate that unit rates for conducting the type test successfully alongwith the offer, which will be considered for evaluation of tender.

ANNEXURE-B

NOTES & DETAILS
FOR
GROUNDING & LIGHTNING PROTECTION SYSTEM

1.00.00 **GENERAL**

1.01.00 These notes and details shall be read and construed in conjunction with grounding and lightning protection drawings and specification. In case of conflict between these notes and drawings, the latter shall prevail.

1.02.00 The grounding and lightning protection system installation work shall conform to the requirements of the latest editions of the following standards/codes :

a) Indian Electricity Rules, 1956.

b) National Electrical Code, 1985.

c) Code of Practice for Earthing (IS: 3043)

d) Protection of Buildings and Allied Structures Against Lightning (IS: 2309)

e) IEEE 80

2.00.00 **GROUNDING SYSTEM**

2.01.00 **Main Grounding Mat/Grid**

2.01.01 The main ground grid shall be buried in earth at a minimum depth of 1000 mm below finished grade level unless stated otherwise. The diameter of ground grid conductor shall be selected by EPC contractor with supporting calculation.

2.01.02 A minimum earth coverage of 300 mm shall be provided between the ground grid conductor and the bottom of trenches, tunnels, underground pipes, foundations, railway tracks etc. The ground grid conductor shall be re-routed in case it fouls with equipment foundations.

2.01.03 In some cases, it may happen that the construction work of cable trench, foundation and laying of underground pipes are being taken up after the grounding mat has been laid. It may be required to cut a portion of grounding conductor to avoid fouling with cable trench, equipment foundations, underground pipes etc. In this case, the ground conductor shall be properly rerouted and rejoined/reconnected with the main grounding mat during the construction/laying of above underground objects and good electrical continuity of grounding conductor shall be ensured.

2.01.04 Grounding conductors crossing the road may have to be laid at greater depth to suit the site conditions.

2.01.05 Grounding conductor around the building shall be buried in earth at a minimum distance of 1200 mm from the outer boundary of the building.

2.02.00 **Grounding Electrodes**

2.02.01 The ground electrodes shall be 3000 mm long, 40mm dia. mild steel rod. These shall be fabricated and driven into the ground by the side of grounding mat conductors and connected to the ground mat conductors.

2.03.00 **Risers**

2.03.01 All risers/pigtail from the ground grid shall be projected 300 mm above grade level/concrete floor level unless otherwise shown.

2.04.00 **Earthing Conductor**

2.04.01 75x 10 mm galvanised steel flats shall be run as main earthing conductors above ground along building columns, walls, steel structure, etc. for equipment and other structures earthing.

2.04.02 These earthing conductors shall be interconnected between them and to the main ground grid through risers/pigtail. The connection between earthing conductor and riser shall be made above ground.

2.04.03 Earthing conductors along their run on column, wall etc. will be supported by suitable welding/clamping at intervals set exceeding 750 mm.

2.04.04 Earthing conductors shall be embedded in concrete floor of the building without having direct contact with the reinforcement rods.

2.04.05 At the crossing of building walls, floors etc. the earthing conductor shall be passed through galvanised conduit sleeves. Both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.

2.05.00 **Grounding of Equipment and Structures**

2.05.01 All indoor and outdoor electrical equipment and associated non-current carrying metal works, supporting structures, building/ boiler columns, fence, system neutrals, lightning masts/arresters shall be connected to the plant ground system.

2.05.02 Two separate and distinct ground connections shall be provided for grounding electrical equipment frameworks in compliance with I.E. rules.

2.05.03 All Electrical equipment will be furnished with two (2) separate ground pads with tapped holes, bolts and spring washers. The connection between these ground pads and the grounding grid shall be made by short and direct earthing conductors free from kinks and splices.

2.05.04 Miscellaneous devices such as junction boxes, pull boxes, pushbutton stations, lockout switches, cable end boxes, lighting fixtures, receptacles, switches etc. shall be effectively grounded whether specifically shown or not.

2.05.05 The generator neutrals, transformer neutrals, earthing terminals of lightning arresters, coupling capacitor shall be directly connected to rod electrodes through riser which in turn, shall be connected to station grounding mat.

2.05.06 Grounding mat comprising closely spaced conductors shall be provided below the operating handles of isolator and circuit breaker operating box located in outdoor high voltage substation. The operating handles shall be properly bonded with flexible conductors.

2.05.07 Metallic conduits and pipes shall not be used as earth continuity conductor. These shall be grounded at both ends.

2.05.08 a) The cable trays inside the cable trenches shall be grounded thru' one (1) no. M.S. Rod at an interval of ten (10) metres. One end of this rod is connected with riser from grounding mat and the other end which is projected inside the cable trench shall be connected with one (1) 50 x 6 mm G.S. flat which runs horizontally along the cable trench. This earthing conductor shall be securely attached to each tray section of cable tray/trays forming a solidly grounded tray system through 50 x 6 mm G.S. flats.

b) A continuous 50 x 6 mm G.S. flat earthing conductor shall run along the supporting structure of overhead cable trays/cable shafts. This earthing conductor shall be attached to each section of cable tray/trays through 50 x 6 mm G.S. flats.

2.05.09 Fence within the ground grid shall be bonded to the plant ground system at regular interval not exceeding ten (10) metres. Fence gate shall be separately grounded with flexible connection to permit movement.

2.05.10 The street lighting poles, junction boxes mounted on the poles, flood light supporting structures etc. shall be connected to ground grid at minimum two points.

2.05.11 The steel columns, metallic stairs, hand-rail etc. of the building where electrical equipment are located shall be connected to the nearby ground mat by earthing conductor. Electrical continuity shall be ensured by bonding the different sections of handrails and metallic stairs.

2.05.12 The railway tracks within plant area shall be bonded across fish plates and the rail tracks shall be connected to grounding grid at different locations. The rail tracks leaving the plant boundary shall be made electrically discontinuous from the rail tracks inside the plant area by providing suitable arrangements at fish plate joints.

2.05.13 The overhead crane rails shall be grounded at both ends. In addition all joints shall be bonded to provide electrical continuity.

2.05.14 The flexible earthing connection of jumpering wire shall be provided where flexible conduits are connected to rigid conduits to ensure continuity.

2.06.00 **Earthing of Cable**

2.06.01 The metallic sheaths, screens and armour of cables shall be earthed at both switchgear/MCC/DB and equipment ends.

2.07.00 **Jointing and Connection**

2.07.01 All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode. The contact surfaces shall be thoroughly cleaned to provide good electrical continuity.

2.07.02 The bending of the large diameter ground conductor where necessary shall be done by gas heating.

2.07.03 The projected portion of riser/pigtail above ground shall be coated with two coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.

2.07.04 The connections between the riser/pigtail and earthing conductors (galvanised steel flats) and between the earthing conductors above ground level shall be made by electric arc welding.

2.07.05 The portion of galvanised steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanising anti-corrosive paint after welding.

2.07.06 The earthing connections to equipment grounding pads/terminals and some removable structures shall be bolted type with GI bolts and nuts. The contact surfaces shall be thoroughly cleaned (to free from scale, paint, enamel, grease, rust) before connection to ensure good electrical contact.

2.07.07 Equipment/structures ground connections after properly checked and tested shall be coated with weather resistant paints/cold galvanising paints.

2.08.00 The sizes and materials of ground conductors used in grounding system are listed below :

	Description	**Size**	**Material**
a)	Main Grounding Grid Conductor	36mm dia. min. higher size if required by calculation.	Mild Steel
b)	Riser/Pigtail From Grounding Grid/Mat	to be decided By Bidder	Mild Steel
c)	Electrode	40mm dia. 3000 mm long.	Mild Steel

	Description	Size	Material
d)	Conductor used for connection of various equipment/structures as listed below		
	E.H.V. Substation equipment	75 x 10 mm Flat	Galvanised Steel
	Generator Frame & Gen Neutral	75 x 10 mm Flat	- Do -
	Generator Exciter Frame	75 x 10 mm Flat	- Do -
	GT, ST, UT Frame	75 x 10 mm Flat	- Do -
	GT, ST, UT Neutral	75 x 10 mm Flat	- Do –
	Aux. Power Transformer Frame	50 x 10 mm Flat	- Do -
	11 kV/3.3kV Equipment	75 x 10 mm Flat	- Do -
	415 V PMCC/Swgr	50 x 10 mm Flat	- Do -
	Structures, Bus Duct, Control Panels, Cable trays, etc.	50 x 6 mm Flat	- Do -
	415V Motor Control Centres, Distribution Boards etc.	50 x 10 mm Flat	- Do -
	Motors upto 5.5kW	8 SWG Wire	
	Motors 5.5kW upto 22kW	25 x 4 mm Flat	- Do -
	Motors 23kW upto 55kW	40 x 6 mm Flat	- Do -
	Motors 56kW upto 174kW	50 x 8 mm Flat	- Do –
	Motors 175kW and above	75 x 10mm Flat	- Do -
	Local Panels, Lighting Panels	50 x 6 mm Flat	- Do -
	Miscellaneous Items, viz. Push Button Station, Junction Boxes etc.	8 SWG Wire	

Note: Sizes of GS Flat as indicated above are minimum. However Bidder shall calculate each of them and submit for approval.

3.00.00 **LIGHTNING PROTECTION SYSTEM**

3.01.00 **Air Terminations**

3.01.01 The vertical air terminal rods shall be installed at the roof of buildings (including power house main building), at the top of chimney and cooling towers to protect these objects from lightning strokes.

3.01.02 The vertical air terminal except for chimney shall be made of 20 mm dia galvanised steel rod. The projected length of the rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.

3.01.03 The air terminal rods provided at the top of chimney/stack for lightning protection shall be 20 mm dia lead coated solid copper rod.

3.01.04 The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of building: the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.

3.01.05 All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size 75 x 10 mm galvanised steel flats.

3.01.06 The shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 degrees.

3.01.07 Horizontal air termination (i.e. G.S. Flat conductor) shall be so laid that no part of the rood will be more than nine (9) metres from the nearest roof conductor.

3.02.00 **Shielding Masts**

3.02.01 The shielding mast for lightning protection shall be installed at the top of steel columns cap plates of power house main building.

3.02.02 The shielding mast shall be made of galvanised steel pipe and the height of the same shall be decided considering the zones to be protected.

3.02.03 Each shielding mast shall be connected to grounding grid by a down conductor 75 x 10 mm. Galvanised steel flat run along the building column. In addition all power house building columns joints shall be electrically bonded.

3.03.00 **Down Conductors**

3.03.01 The down conductors shall be 75 x 10 mm galvanised steel flats. The sizes of down conductors and horizontal conductor provided for lightning protection of conveyer gallery shall be 25 x 6 mm galvanised steel flats. One end of this shall be connected with air terminal rod/horizontal conductor at the top of roof/structure and other end connected to the nearest 40 mm dia. mild steel rod riser from ground electrode.

3.03.02 Each down conductor shall have an independent earth termination. In no case conductors of the lightning protection system shall be connected with the conductor of grounding system above ground level.

3.03.03 The connection between each down conductor and rod electrode shall be made via test link located at approximately 1500 mm above ground level.

3.03.04 The down conductor shall be laid straight and sharp bends shall be avoided as far as practicable. These shall be cleated on outside of the building wall

and column/structure at about 750 mm intervals unless stated otherwise in the drawing.

3.03.05 At all supports for down conductor along the column/wall of the buildings; chimney etc. the portion embedded inside the building concrete should not touch the reinforcement bars.

3.03.06 All exposed metallic parts of the buildings shall be bonded to the down conductors. Such parts shall include ladders, balconies, conduits etc.

3.03.07 The down conductors shall be protected at the ground level against mechanical injury by means of non-metallic pipes, viz. PVC pipes filled with bituminous compound.

3.04.00 **Electrodes (for Lightning Protection)**

3.04.01 The electrodes shall be 3000 mm long, 40mm dia. mild steel rod. These shall be driven into the ground.

3.04.02 All the electrodes shall be interconnected by means of one mild steel rod which will be laid under ground at a minimum depth of 1000 mm below finished grade level unless stated otherwise. This ground mat/electrode in turn shall be connected to main grounding grid.

3.05.00 **Riser (for Lightning Protection)**

3.05.01 All risers connected to grounding mat shall be projected 300 mm above grade level unless stated otherwise.

3.06.00 **Jointing & Connection**

3.06.01 All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode.

3.06.02 The projected portion of riser above ground shall be coated with two (2) coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.

3.06.03 The joints in the lightning conductors shall be kept to a minimum and there shall be no joint in the underground portions of conductors.

3.06.04 All the joints shall be done by arc welding process overlapping of the conductors at straight joints shall not be less than 150 mm. The contact surfaces shall be cleaned properly before jointing.

3.06.05 The portion of galvanised steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanising anti-corrosive paint after welding.

3.06.06 The bolted joint of the test link shall be covered with thick coating of bitumen paint after successful testing.

3.06.07 The air terminal rods and shielding mast shall be coated with weather resistant anti-corrosive paint (zinc chromate followed by two coats of aluminium paint).

3.06.08 The steel to copper connection shall be brazed type.

3.07.00 **Lightning Protection of 400kV Switchyard & Other areas**

3.07.01 The lightning protection of outdoor switchyards/substation shall be done by lightning masts on the top of steel towers. In addition, shield wires shall be used where required. The shield wire shall be strung across the top of the steel tower and/or powerhouse structure.

3.07.02 The shield wire which shall be brought down up to bottom of steel tower shall be connected to the earthing conductor (50 x 6 mm galvanised steel flat) which in turn connected to the riser (from the main grounding mat/grid).

3.07.03 The lightning protection of inflammable liquid storage tanks wherever required, shall be provided with horizontal conductors strung between tall poles covering the entire zones or with air terminal rods mounted on top of poles/structure. These horizontal conductors/vertical air terminal rods shall be connected to rod electrodes, which in turn shall be connected to station ground mat.

3.07.04 The lightning protection of conveyor gallery shall be provided with horizontal conductors (25 x 6 mm G.S. Flat) run along the length of the conveyor gallery at the top of gallery roof. This conductor shall be connected to riser and grounding electrode at an approximate interval of 30 mm through two down conductions (each 25 x 6 mm G.S. Flats).

3.08.00 The sizes and materials of earthing conductors to be used in lightning protection system are listed below :

	Description		**Size**	**Material**
a)	Vertical Air Termination		20 mm dia Rod (Chimney)	Lead Coated Copper rod.
b)	Vertical Air Termination (Except Chimney)		20 mm dia Rod	Galvanised steel
c)	Horizontal Conductor	i) ii)	75 x 10 mm Flat 25 x 3 mm Flat	- Do - - Do -
d)	Down Conductors	i) ii)	75 x 10 mm Flat 25 x 3 mm Flat	- Do - - Do -
e)	Riser From Electrode/ Grounding Mat		to be decided by Bidder	Mild Steel
f)	Electrode for Lightning Protection		3000 mm long , 40mm dia.	Mild Steel

Note :

In addition to above, all materials as required such as G.I. pipes of appropriate length, diameter and thickness will be provided for lightning masts of Power House building and Switchyard.

1. All the cable tray installation and cabling work will be carried out as per the following drawings and document of respective areas :

   i) Equipment and Cabling Layout.
   i) Grounding Layout.
   ii) Cable Schedule and inter-connection Chart.

   In the above layout drawings, the main routing of cable trays/trenches are shown upto nearest point of any equipment. Local routing of cable trays/cables (from above main routing) upto respective equipment will be decided by the EPC contractor at site.

2.a) Except at panels/enclosure, the conduit ends shall be sealed by suitable sealing compound, having fire withstand capability.

   b) Cables laid on trays and risers shall be clamped at an interval of 1500mm and 900mm for horizontal & vertical cable runs respectively.

   c) All single core power cables shall be laid in trifoil formation and suitably clamped.

3. Based on the drawings and details indicated above in this document, EPC contractor shall estimate and supply all necessary cable tray supports, conduits, clamps, hardwares, etc. to make the installation complete in all respect.

4. Typical arrangement of fixing cable trays in cable trenches/overhead are shown in this document. EPC contractor will supply and install all necessary supporting steel structures for erection of cable trays.

5. Cables shall be laid as follows

   On cable trays
   In duct bank.
   Directly burried (for street lighting only and as specified in the layout drawings)

6. Laying of Cables shall be carried out as per IS:1255. Cabling work shall comprise of the following as/or as stipulated in the specification :-

   On Tray : laying, dressing, clamping of cables on tray, fixing of cable tag including supply of cable clamps, cable tags and fixing hardware. Trifoil clamps shall be provided for single core cables laid in trifoil arrangement.

   Buried : excavation of earth, filling by sand, providing brick partition, laying and dressing of cable, fixing of cable tag, sand covering followed by fixing of precast cover, backfilling by good earth followed by coarse earth including the supply of cable tag, sand, brick, precast cover.

   Shallow trench : laying, dressing, fixing of cable tag, filling with sand and fixing of brick column including supply of sand, brick and cable tag.

   Duct bank : pulling of cable and fixing of cable tag.

A4_DD (9-96) [210x297]

7. HT Multicore Power cables of same voltage grade shall be laid in a single row with D gap between cables where D is the largest dia.adjacent of cable and in case of singlecore cable laid in trefoil formation with a distance of four times. The dia. of cable between trefoil centre line and clamped at every 2m. LT Multicore Power cables shall be laid touching in a single row and singlecore cables to be laid in trefoil formation with a distance of four times. The dia.of the cable between trefoil centre lines and clamp every 2m. Control & Instrument cables shall be laid in multiple rows upto a maximum of three rows.
   At least 300mm clearance shall be maintained between cables of different voltage grades & services like power, control and instrumentation.
   The laying sequence of cable of various voltage levels shall be as follows (from top to bottom) :-

   HT power cables
   LT power cables
   Control cables
   Instrumentation & Communication system cables.

8. For Power cables clamping of adjacent cables on the same tray shall be staggered to avoid fouling of the clamping bolts.

9. Termination work shall be done in accordance with the stipulation of the specification including supply of lugs and glands for control cables.

10. Armour/screen of multi-core cables shall be grounded at both ends. Armour/screen of single core cables shall be grounded only at source end.

11. Indelible identification tags shall be provided for all cables at all terminations just before entering the equipment enclosure, on both side of a wall or floor crossing, on each duct/conduit entry and at every twenty metres in cable tray/trench. Cable trays along a route shall also be systematically numbered and marked to ensure cable laying according to cable schedules. Beside having identification/designation at each end of cable way and branch connection, long length of trays shall have identification at every 10 metres.

12. Whenever cables pass through walls or floors, fire proof penetration seals rated for 90 min. shall be provided.

13. Street lighting cables shall be routed buried and at road crossings lighting cables shall pass through 150mm dia. hume pipes(Class NP-3) Above pipes shall be installed at a min. depth of 1000mm from ground level.

14. RCC trenches, Pull pits & Hand holes in Hazardous area shall be filled up with sand after cable laying.

15. No cable joints are permitted for cable runs less than 500m.

16. Earthing of cable trays shall be provided as per Dwg. no. 13A06-DWG-E-0600.

A4_DD (9-96) [210x297]

GROUNDING NOTES

1.0 *These grounding notes and details shall be read and construed in conjunction with grounding drawings and specification.*

2.0 *The grounding installation work shall conform to the requirements of the Indian Electricity Rules and code of Practice for Earthing (IS:3043) as amended up-to-date in India. For the work in other country, the statutury rules and code of practice in vogue there in shall be followed.*

3.0 *The main ground grid shall be buried in earth at a minimum depth of 1000 mm below grade. A minimum earth coverage of 300 mm shall be provided between the ground grid conductor and the bottom of trench/foundation/underground pipe at the crossing.*

4.0 *Ground grid conductors around a building/switchyard fence shall be buried outside the boundary at a minium distance of 1500 mm.*

5.0 *A additional grid of 1500 mm x 1500 mm comprising of closely spaced (300 mmx300 mm) coductor at a depth of 300 mm from finished grade level shall be provided below the operating handle of Isolators and Circuit Breaker operating boxes located in outdoor HV/EHV substation. This grid shall be connected to the main ground grid.*
The ground connection to operating handle shall be made of flexible connection.

6.0 *The ground grid conductor below grade shall be of bare mild steel rod of adequate size. Ground electrode shall be of same diameter of grid conductor and 3000 mm long mild steel rod, driven into the ground and connected to the ground grid conductor.*

7.0 *Riser/pigtail from the ground grid shall also be mild steel rod of same diameter of grid conductor and shall prroject 300 mm above grade/concrete floor level unless otherwise shown.*

8.0 *All ground connections below grade shall be made by electric arc welding with low hydrogen content electrode. Bending of the conductor where necessary shall be done by gas heating.*

9.0 *Above grade, galvanised mild steel flats shall be run as main ground conductors along building steels, walls and cable trays and securely fixed to the same by welding/clamping at intervals not exceeding 1500 mm.*
The ground conductors shall be interconnected between them and to the main ground grid through risers.

* *Exact diameter of ground rod shall be selected by EPC contractor with back-up calculation.*

A4_DD (9-96) [210x297]

10. *All electrical equipment and associated non-current carrying metal works, supporting structures, building/boiler columns,fence, system neutrals, lighting masts/arresters shall be connected to the plant ground system.*

11. *Two seperate and distinct ground connections shall be provided for grounding of electrical equipment frameworks.*

12. *Miscellaneous devices such as junction boxes, pull boxes, push-button stations, lockout switches, cable end boxes etc. shall be effectively grounded whether specifically shown or not.*

13. *Ground conductor connections above grade shall be generally made by electric are welding. The connection shall be coated with cold galvanising/weather resistant anti corrosive paints.*

14. *Bolted connection shall be made only for grounding of equipment/ devices and some removable structures. The contact surfaces shall be throughly cleaned before connection to ensure good electrical contact.*

15. *A continuous 75 x 10 mm galvanised M.S flat ground conductor shall be installed along the cable raceway and securely attached to each tray section, forming a solidly grounded tray system.*

16. *A 16 Swg G.I. wire shall be run along the metalic conduit and shall be securely tied with the same at an internal 300 mm.*

    Grounding connection or wire jumpers shall be installed where flexible conduit is used to connect rigid conduit to equipment.

17. *Crane rails shall be grounded at both ends. in addition all joints shall be bonded to provide electrical continuity.*

18. *Fence within the ground grid shall be bonded to the plant ground system at regular interval not exceeding ten(10) meters. Fence gate shall be separately grounded with flexible connection to permit movement.*

19. *For shielding, the ground conductors shall be taken right upto the top along the structure/chimney and connected directly to the lightning masts.*

20. *The poles used for distribution line and / or street light shall be grounded at the bottom.*

A4_DD (9-96) [210x297]

21. Ground electrodes shall be provided at connections with generator/ transformer neutrals, lightning arresters and lightning masts.

22. For ground connections, the conductor sizes shall be as listed below :-

	Equipment		Size	Material
a.	EHV Substation equipment	:	75 x 10 mm	Galvanised steel
b.	Generator Frame & Gen. Neutral	:	75 x 10 mm	Galvanised steel
c.	generator Exciter Frame	:	75 x 10 mm	Galvanised steel
d.	GT, ST, UT Frame	:	75 x 10 mm	Galvanised steel
e.	GT, ST, UT Neutral	:	75 x 10 mm	Galvanised steel
f.	Auxiliary Power Transformer Frame	:	50 x 10 mm	Galvanised steel
g.	11kV/3.3kV Equipment	:	75 x 10 mm	Galvanised steel
h.	11kV/3.3kV Switchgear	:	75 x 10 mm	Galvanised steel
i.	415V PMCC/SWGR	:	50 x 10 mm	Galvanised steel
J.	Structures, Bus Duct, Control panels, etc.	:	50 x 6 mm	Galvanised steel
k.	415V Motor Control Centres, Distribution Booards etc.	:	50 x 10 mm	Galvanised steel
l.	Local Panels Lighting Panels, Cable Trays etc.	:	50 x 6 mm	Galvanised steel
m.	Motors :			
	Motors upto 5.5kW	:	8 SWG Wire	
	Motors 5.5kW upto 22kW	:	25 x 4 mm	Galvanised steel
	Motors 23kW upto 55kW	:	40 x 6 mm	Galvanised steel
	Motors 56kW upto 174kW	:	50 x 8 mm	Galvanised steel
	Motors 174kW and above	:	75 x 10 mm	Galvanised steel
n.	Miscellaneous items, viz. Push Button Station, JB etc.	:	8 SWG Wire	

A4_DD (9-96) [210x297]

1.0 AIR TERMINATIONS

1.1 Vertical air terminal rods shall be installed on the top of all structured/buildings to be protected from lightning strokes.

1.2 Vertical air terminal except those for chimney shall be 20 mm dia galvanised steel rods. The projected length of the rods including mounting structure, if any, shall be as required to protect the objects, from lightning stroke. Air terminal rods provided on top of chimney/ stack for lightning protection shall be 20 mm dia lead coated solid copper rods.

1.3 Air terminal rods shall be properly fixed on top of buildings/ structures to withstand wind pressure.In case the air terminal rods are embedded in the building roof, the portion embedded in the contrete shall not touch the reinforcement bars and shall be duely insulated from them.

1.4 All vertical air terminal rods shall be electrically connected by means of horizontal conductors (galvanised MS flats) of size 75 x 10 mm.

1.5 The shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 degrees.

1.6 Horizontal air terminations (galvanised MS flats) shall be so laid out that no part of the roof is more than nine (9) metres away from the nearest Horizonal air terminals.

2.0 SHIELDING MASTS

2.1 The shielding mast for lightning protection shall be installed on top of the steel column cap plates of power house main building.

2.2 The shielding masts shall be made of galvanished steel pipe and the heights of the same shall be decided considering the zones to be protected.

2.3 Each shielding mast shall be connected to grounding grid of the station by a 75 x 10 mm. galvanised MS down conductor running along the building column. In addition, all power house building column joints shall be electrically bonded.

3.0 DOWN CONDUCTORS

3.1 The down conductors shall be 75 x 10 mm galvanished MS flats. However, The down conductor of conveyor gallery may be 25 x 3mm galvanised MS flats.

One end of these flats shall be connected to the air terminal rods/ horizontal conductors on top of roof/structure and the other end to the nearest earth terminals.

3.2 Each down conductor shall have an independent earth termination. In no case conductors of the lightning protection system shall be connected with the conductors of the grounding system above ground

A4_DD (9-96) [210x297]

3.3 The connetion between each down conductor and earth terminal shall be made via test link located at approximately 1500 mm above ground level.

3.4 The down conductors shall be laid straight and sharp bends shall be avoided as far as practicable. These shall be cleated on the outside of the building wall and or columns/structures at intervals of about 750 mm., unless indicated otherwise in the drawings.

3.5 Down conductors along the chimney shell shall be electrically connected with the reinforcement rods by suitable lugs welded (6 mm fillet) to both down conductor and reinforcement at the interval of 30 mm.

3.6 All exposed metallic parts of a building shall be bonded to the down conductors. Such parts shall include ladders, balconies, conduits etc.

4.0 EARTH TERMINALS.

4.1 Where ground mat is available, the risers specifically ear-marked for lightning protection shall be considered as Earth Terminal. In such case, one electrode shall be provide close to the each Earth Terminals.

4.2 Where ground mat is not available sparate earth pit as per IS-3043 or approved international standard specifically for lightning protection shall be provided as Earth Terminal.

5.0 JOINTING & CONNECTION

5.1 Number of joints in the lightning conductors shall be kept to a minimum.

5.2 All the joints shall be done by arc welding process. Overlapping of conductors at straight joints shall not be less than 150 mm. The contact surfaces shall be properly cleaned before jointing.

5.3 Those portions of galvanished steel flats, which have been welded at site, shall be coated with two (2) coats of cold galvanising anti-corrosive paint after welding.

5.4 After successful testing the bolted joints of test links shall be wrapped by bitumenons hessian tape followed by 3 mm thick coating of bitumen compound.

5.5 Air terminal rods and shielding masts shall be coated with weather resistant anti-corrosive paint (zinc chromate followed by two coats of aluminium paint).

5.6 Steel to copper connection shall be brazed type.

A4_DD (9-96) [210x297]

6.1 Lightning protection of outdoor switchyards/substations shall be done by lightning masts on top of steel towers. shield wires may also be used wherever required. These shall be strung across the top of the steel towers and/or building/plant structure.

6.2 The shield wire, which shall be brought down to the bottom of the steel towers, shall be connected to the earthing conductor (50 x 6 mm galvanished MS flat), which in turn, shall be connected to the riser from the main grounding mat/grid.

6.3 For lightning protection of conveyor gallery, a horizontal conductor (25 x3 mm galvanised MS flat) running along the entire length of the conveyor gallery shall be provided on top of the gallery roof. This conductor be connected to a earth terminal at approximate intervals of 30M by two down conductors, each 25 x 3 mm galvanised MS flat.

7.0 The sizes and materials of earthing conductors used in lightning protection system are listed below :

	DESCRIPTION		SIZE	MATERIAL
a)	Vertical Air Terminals (Chimney/stack)		20 mm dia rod	Lead coated solid copper rod.
b)	Vertical Air Terminals (Other than chimney)		20 mm dia rod	Galvanised mild steel
c)	Horizontal conductors	i)	75 x 10 mm Flat	Galvanished Mild steel
		ii)	25 x 3 mm Flat	Galvanished Mild steel
d)	Down Conductors	i)	75 x 10 mm Flat	Galvanished Mild steel
		ii)	25 x 3 mm Flat	Galvanished Mild steel
e)	Riser From Electrode/ Grounding Mat		40 mm dia Rod (Min.)	Mild Steel
f)	Electrode for Lightning Protection		40 mm dia Rod(Min.) 3000 mm long	Mild Steel

* Exact diameter of the ground rod shall be selected by EPC contractor with back-up calculation

A4_DD (9--96) [210x297]

VOLUME : V-B

SECTION-VII

TECHNICAL SPECIFICATION FOR ILLUMINATION SYSTEM

CONTENT

CLAUSE NO.	DESCRIPTION
1.00.00	SCOPE OF WORK
2.00.00	SCOPE OF SUPPLY
3.00.00	SCOPE OF SERVICE
4.00.00	GENERAL REQUIREMENTS
5.00.00	DESIGN CRITERIA
6.00.00	SPECIFIC REQUIREMENTS - SUPPLY
7.00.00	SPECIFIC REQUIREMENTS - SERVICES
8.00.00	TESTS
9.00.00	DRAWINGS DATA & MANUALS

ATTACHMENTS

ANNEXURE-A	AVAILABLE POWER SUPPLY
ANNEXURE-B	TYPES OF LIGHTING EQUIPMENT
ANNEXURE-C	ILLUMINATION LEVEL
ANNEXURE-D	RATINGS AND REQUIREMENTS OF LIGHTING TRANSFORMER
ANNEXURE-E	FITTINGS AND ACCESSORIES OF LIGHTING TRANSFORMER

SECTION-VII

TECHNICAL SPECIFICATION FOR ILLUMINATION SYSTEM

1.00.00 SCOPE OF WORK

1.01.00 This scope of work shall cover the design, manufacture, assembly, testing at manufacturer's works, supply & delivery, properly packed for transport F.O.R. site of STATION LIGHTING SYSTEM, complete with all materials and accessories for efficient and trouble-free operation.

1.02.00 The scope of work shall also include complete installation, testing, commissioning and putting into successful commercial operation of the Lighting System of all the buildings and facilities included under this Contract inclusive of supply of all labour, tools, implements and supplies.

2.00.00 SCOPE OF SUPPLY

2.01.00 The equipment and materials within the scope of supply shall include but not limited to:

a) Lighting / Welding Transformer.

b) Lighting fixtures with lamps and accessories.

c) Main lighting distribution boards, Lighting panels/boards, Emergency lighting boards, emergency DC lighting panels, street lighting panels etc. All panels shall be provided with energy saving system.

d) Street light poles, flood lighting tower/poles/high masts.

e) Ceiling fans, receptacles, switches, switchboards, portable emergency lights, portable 24V supply module including handset maintenance equipment etc.

f) Separate DB for 1ph, 240 V power supply is required to be indicated suitably for miscellaneous services supplies.

g) Separate DB for 24 V power supply is required to be indicated suitable for 24 V lighting supply.

h) Separate DB with transformers is required to be considered for welding receptacles.

i) Cables, wires, splicing/termination/connection accessories.

j) Conduit and accessories, junction and pull boxes, terminal blocks.

k) Grounding materials and connections.

l) All fittings, supports, brackets, anchors, clamps and connections.

m) Steel for field fabrication of supports and brackets.

2.01.01 Data sheets and technical leaflets on each piece of equipments / devices

3.00.00 SCOPE OF SERVICE

3.01.00 Carrying out of detail engineering including detail design calculations, preparation of lighting layouts showing location of fixtures, cable wires and conduit routing, preparation of cable schedule, and other related drawings as detailed in subsequent clauses and also consider the energy saving system.

3.01.01 Furnishing of all labour, skilled and unskilled, supervisory personnel, erection tools and tackles, testing equipment, implements, supplies, consumables & hardware, and transport for timely and efficient execution of the contract work.

3.01.02 Preparation of AS-BUILT drawings showing field modifications, if any.

4.00.00 GENERAL REQUIREMENTS

4.01.00 Codes and Standards

Major standards, which shall be followed, are listed below. Other applicable Indian standards even if not covered in the listed standard shall be followed.

a) IS-1913

b) IS-1977

c) IS-10322

d) IS-8623

e) IS-6064

f) IS-8828

g) IEC-598

h) IS-13703

i) IS-13947

j) IS-1248

k) IS-2705

l) IS-4160

m) IS-2713

n) IS-800

o) IS-2026

p) IS-2099

q) IS-694

r) IS-1554

s) IS-9537

t) IS-14772

u) IS-5133

5.00.00 **DESIGN CRITERIA**

5.01.00 **Design Basis**

5.01.01 The system provides lighting and electric power supply to Main plant & BOP areas, extension part of 400kV switchyard, peripheral roads inside boundary wall, non service areas, etc. under the scope of this contract. In addition, it also provides lighting to selected areas during plant emergency conditions.

5.01.02 The system will be installed in an adverse industrial environment. Equipment in some areas will be subject to vibration, coal-dust, fly-ash, oil/water vapours as prevalent in a thermal generating plant.

5.01.03 The design shall be such as to provide minimum lighting levels as specified for different areas. The Bidder shall carefully consider these lighting levels and layouts in making the offer and shall clearly indicate if any change is required to achieve the design lighting levels with the equipment offered.

5.01.04 The systems shall be suitable for operation on available power supply having characteristics as given in the annexure.

5.01.05 All fittings of control room / office shall be energy efficient type.

5.01.06 The main plant/auxiliary building/other BOP area shall generally be provided with :

- Main lighting system for full illumination under normal power supply conditions and shall operate from 415V/240V AC power supply tapped from respective MLDB/lighting panels.

- Emergency lighting system for reduced illumination operated by DG supply feeders during failure of main power supply. It shall cover 20% of fixtures in the building and associated area.

- Minimum emergency lighting system for reduced illumination during failure of main power supply with the help of 220V DC batteries/supply feeders. This is applicable for Coal Handling Plant also. Regarding lux level of emergency lighting in CHP area, refer to Annexure-B.

5.01.07 Various lighting panel shall be fed directly from nearest Main Lighting Distribution Board and these MLDB s shall be subsequently fed from respective 415V switchgear/PMCC through 1:1 transformers to reduce fault level. If the fault level can be contained within 9 kA by virtue of cable impedances, use of 1:1 transformer can be dispensed with.

5.02.00 **System Concept**

The lighting system shall comprise following sub-systems:

5.02.01 Normal A.C. Lighting

This will be provided by A.C. lighting fixtures distributed throughout the plant area. These lights will be ON as long as the station A.C. supply is available.

A.C. lighting fixtures will be fed from respective area lighting panels, which in turn will be connected to main lighting distribution board. The main lighting distribution boards (MLDB) shall have 2x100% incomers and bus-coupler and be fed through 2x100% lighting transformers, which forms a part of the MLDB. Normal A.C. supply thus made available by the MLDB is 415V-3ph-4W-50HZ effectively grounded. Both the MLDB & the lighting panels shall be provided with at least 20% spare outlets.

Arrangement shall be made for automatic light control in switchyard, boiler gallery, ESP area, turbine floor (high bay) area as required during day time.

5.02.02 Normal cum Emergency A.C. Lighting

a) On failure of normal A.C. Supply, emergency A.C. lighting will be provided in selected areas of the powerhouse, boiler area, boiler galleries etc for general visibility, safe movements and operation of important auxiliaries.

b) The emergency MLDBs (EMLDB) are similar to the MLDB except that lighting transformers in this case are fed from station A.C. Emergency bus having D.G. System backup. Thus power for A.C. emergency lighting is 415V-3ph-4W, 50HZ, effectively grounded.

These lights will be kept "ON" from normal power supply source and upon its failure will be fed from DG.

c) A.C. emergency lighting fixture will account for 20% of the total lighting fixtures provided in the above mentioned area. In main control room 30% emergency lighting shall be provided.

5.02.03 Emergency D.C. Lighting

a) This will be provided by emergency D.C. lighting fixtures located strategically in critical operating areas and emergency exits to enable safe movement of operating personnel access to important control points when both the normal AC and Emergency lighting system fails. These lighting fixtures will be fed from DC lighting panels which in turn will be fed from 220V DC LDB. The supply to DC lighting panels will be automatically switched ON in case of loss of plant normal &

emergency AC supply. The DC lights will be switched OFF after about 3 minutes following restoration of normal AC or emergency AC supply.

b) Emergency DC Lighting (CHP Area)

100W, 220V DC lighting fixture shall be provided in underground portion of conveyor, each switchgear room, control room, office room, pump house, each drive floor of TPs, staircase of TPs, buildings and local control area. DC lighting fixtures will be fed from 220V DC LDB, which in turn will be fed from CHP DC system.

5.02.04 24V, 1 ph AC maintenance lighting system

Separate DB for 24V power supply shall be provided for 24V maintenance lighting.

5.02.05 Street/Area Lighting

Time switch and photocell will be used for controlling area lights with provision for manual override and also have the provision of latest Energy Saving Systems.

.

Same arrangement will also be used for controlling, boiler gallery, ESP area, turbine floor (high bay) area illumination.

5.02.06 Remote Emergency Lighting

This will be provided in auxiliary/off-site buildings except CHP where D.C. supply is not available by self-contained battery / automatic charger/inverter/flood light units. These portable emergency light units will be energized automatically on loss of normal A.C. supply.

5.03.00 **Ratings & Requirements**

5.03.01 All equipment and accessories shall be designed for continuous operation under site conditions without exceeding permissible temperature rise as stipulated in relevant standards.

5.03.02 Switch, fuses, MCCB, miniature circuit breakers (MCB), busbar shall be fully rated for short circuit level at the point of application. MCB shall have back-up HRC fuse if its rating is less than the available short circuit current.

5.03.03 All equipment and accessories shall have proper enclosure to suit the site conditions. Hazardous areas shall have flame-proof enclosure.

5.03.04 All wiring from lighting panels to fixtures and receptacles shall be carried out by PVC wires in G.I. Conduits.

5.03.05 Heavy duty XLPE FRLS cables as pre cable specification will be used for connections :

a) From main lighting board to area lighting panels

b) From street/area lighting panel to street light poles.

c) From Welding DBs to receptacles of 63A and above

5.03.06 The lighting system will be supplied from 415V/415V ± 5%, indoor, dry type lighting transformers. However it shall be so chosen to limit the fault level within 9kA.

5.03.07 Suitable number of Flood Lighting Towers / Lighting Masts with adequate HPSV Flood Light will be provided for necessary outdoor areas as required.

5.03.08 Lighting of all main streets, approach roads to various buildings shall be included.

5.03.09 Each lighting panel shall be provided with adequate number of outgoing miniature circuit breaker for controlling fixtures. 5A, 5 Pin sockets shall be fed from the lighting panel through separate circuits.

5.03.10 All A.C. Normal and Emergency A.C. lighting shall be provided with Energy Saving System.

5.04.00 **Method of Calculation**

5.04.01 Standard Lumen method shall be adopted for interior & exterior lighting in order to determine the number of lighting fixtures for obtaining the desired average level of illumination.

5.04.02 The coefficient of utilization shall be considered to take care of Lumen loss due to :

a) effect of room dimensions.

b) absorption of light in luminaires.

c) absorption of light at various room surfaces, i.e ceiling wall etc.

d) floor cavity, ceiling cavity.

e) mounting height.

5.04.03 Moreover a maintenance factor shall also be considered to account for the fall of illumination due to aging, pollution like dust deposit etc. Maintenance factors to be considered for various areas shall be as follows :

Area	**Maintenance factor**
Control Room	0.75
Switchgear/MCC Room	0.65
General indoor area	0.60
Dusty Area	0.55

Light loss Factor

It is recommended that in interiors with fairly clean atmosphere, for example, offices, air conditioned control rooms etc, a light loss factor of 0.8, in interiors which are prone to accumulate dust faster, for example, most in industrial interior an LLF of 0.7 and in high dirt prone interiors an LLF of 0.6 may be adopted for calculating the no. of luminaires to be installed for a particular service illuminance.

5.04.04 To achieve the recommended luminance relationship, it is necessary to select the reflectance of all finishes of the room surfaces. The recommended reflectance values for industrial interiors and equipment are given below for bidder's guide lines:

(For station / other BOP area except CHP)

Surface	Reflectance Percentage
Ceiling	80-90
Wall	40-60
Desk and Bench tops, machines And equipment	25-45
Floor	not less than 20

CHP Requirement:-

For Dusty area such as conveyor galleries, TPs, crusher house etc.:

Surface	Reflectance Percentage
Ceiling	50
Wall	30
Floor	10

5.04.05 Lux level to be considered for various areas are given in Annexure-C.

5.04.06 Voltage drop at the fixture from the MLDB bus shall not exceed 3%.

5.04.07 Circuit loading of each lighting Panel shall be done in such a way that almost balanced loading in all the phases i.e. R, Y & B is achieved.

5.04.08 At least two sub circuits shall be used for illumination of a particular area.

5.04.09 Sub circuit loading of each lighting panel shall be restricted to 2000 Watts.

6.00.00 SPECIFIC REQUIREMENTS - SUPPLY

6.01.00 Equipment and Material

6.01.01 Equipment and material shall comply with description, rating, type and size as detailed in this specification, drawings and annexures.

6.01.02 Equipment and materials furnished shall be complete and operative in all details.

6.01.03 All accessories, control devices, internal wiring, fittings, supports, hangers, anchor bolts etc. which form part of the equipment or which are necessary for safe and satisfactory installation and operation of the equipment shall be furnished.

6.01.04 All parts shall be made accurately to standard gauges so as to facilitate replacement and repair. All corresponding parts of similar equipment shall be interchangeable.

6.02.00 **Lighting/Welding Transformers & Lighting Fixtures**

6.02.01 Each AC Lighting Distribution Board (MLDB) / Welding DB shall be fed from a transformer. The transformers shall be dry type, indoor type dusty vermin proof having 415V / 415V ± 2 x 2.5% with off load tap-changer on primary side. The vector-group shall be Dyn11. (The secondary side shall be solidly grounded through an additional neutral bushing exclusively used for grounding.)The casing of the transformer shall be grounded at least at two (2) points. The transformer may be located inside the lighting / welding DB itself or by the side of respective DB. Impedance of the transformer shall be so selected such that fault level of lighting/welding system is reduced to 3-5 kA.

6.02.02 If necessary, apart from the main lighting transformers, separate small additional lighting transformers may be used at distance lighting points.

6.02.03 Lighting fixtures shall be designed for minimum glare. The surface finish shall be smooth, unobtrusive and scratch resistant.

6.02.04 Reflector shall be of sheet steel or aluminium, minimum 20 SWG thick, securely fixed by fastening device of captive type.

6.02.05 Fixture shall be suitable for 20 mm conduit entry and 16 SWG G.I. earth wire connection.

6.02.06 High bay fixtures shall have provision for vibration damper to ensure rated lamp life. Cost of each damper shall be separately indicated.

6.02.07 Fixture shall be furnished complete with lamps and integrally/non integrally or separately mounted control gear & accessories as applicable for different types of fixtures. These shall include holders, ballast, capacitor, starter, ignitors, etc.

6.02.08 Fixtures shall be fully wired up to respective terminal blocks, suitable for loop in and loop out connection of PVC wires of following sizes :

a) Lighting fixture : 2.5 mm^2 Copper

b) Flood Light fixture : 2x2.5 mm^2 Copper

6.03.00 **Lamps**

6.03.01 General lighting service (GLS) lamps shall be with clear glass and screwed caps.

6.03.02 All fluorescent lamp shall be bi-pin rotary type. Lamp holder shall be spring loaded, low contact resistance type and shall have resistance to wear. CFL and T5 fluorescent tube with electronic ballast or tri-phosphorous tube

Fluorescent lamp will be used in indoor application having low height like 3 to 5 metres requiring good colour rendering. All control rooms, electrical panel room, auxiliary building, laboratories, office area, etc. will be provided with fluorescent lamp fixtures. The fluorescent lamp will be tubular, cool daylight type of 28W as per annexure.

6.03.03 Mercury/Sodium vapour lamp shall be colour corrected type with screwed cap.

HPSV lamp has the advantage of very high efficiency (lumens/watt) and hence recommended for indoor application with elevation more than 4 meters such as TG Hall, Boiler & ESP platform, Pump House and all outdoor application such as area lighting, roads, boundary wall, etc. Flameproof fixtures will be used for hazardous areas with HPMV lamps. The HPSV/ HPMV lamps will be elliptical of rating 70W/150W/250W/400W as required depending on application. For all indoor application in CHP area such as conveyor galleries / tunnels and floor below 4m, 35W low pressure sodium vapour / 70W HPSV shall be considered.

6.03.04 Lamps shall be suitable for use in position and capable of withstanding small vibrations. Restrictions and special features, if any, shall be clearly indicated in the bid.

6.04.00 **Ballast/Electronic Ballast**

6.04.01 Ballasts shall be heavy duty, low loss, polyester-filled type with copper winding. Ballast shall be free from hum.

6.04.02 Ballast for Mercury/Sodium vapour lamp shall be provided with suitable tapping to set the voltage within range specified.

6.04.03 In multi-lamp fixture, each lamp shall be provided with individual ballast.

6.04.04 Ballast windings shall have maximum operating temperature of 120^{o}C without rated temperature rise marking.

6.04.05 Electronic Ballast shall be suitable for 220 V DC and also 240 V AC.

6.04.06 Electronic Ballast shall be compact, lightweight, high frequency electronic standard ballast for fluorescent lamps.

6.04.07 It shall be Flicker-free warm start, ideal for areas with high switching frequency.

6.04.08 Electronic Ballast shall be of such design that minimum 25% reduction in energy consumption at constant luminous flux compared with conventional gear.

6.04.09 Electronic Ballast shall not cause high harmonic distortion.

6.04.11 Electronic Ballast shall provide constant light independent of mains voltage fluctuation.

6.05.00 **Lighting Panel/Distribution Boards**

6.05.01 Lighting Distribution Boards/panels shall be metal-enclosed, cabinet type, fabricated from CRCA sheet steel minimum 2 mm thick, suitable for either wall/column mounting on brackets or floor mounting on channel sills.

6.05.02 Indoor Lighting Distribution Boards & Lighting Panels shall be dust and vermin-proof, IP-52 or better; outdoor panels shall be weather-proof with canopy, IPW-55 or better. The cubicle-housing transformer shall be minimum IP-42.

6.05.03 Lighting Distribution Boards and Lighting Panels shall be so constructed as to permit free access to the terminal connections and easy replacement of parts. Front access doors shall have padlocking arrangements.

6.05.04 Lighting Distribution Boards shall have provision of cable entry from bottom and, panels shall have provision of cable entry from top and bottom, as required, with removable gland plates. Necessary double compression type brass cable glands, tinned copper/Aluminium cable lugs are to be furnished.

6.05.05 Two ground pads with M10 G.I. bolts and nuts shall be provided on each Lighting Distribution Board and Lighting Panel for connection to ground conductor.

6.05.06 Each Lighting Distribution Board shall be complete with designation and caution notice plates fixed on front cover and a directory plate fixed on inside of the front cover. This directory plate shall contain details of the Lighting Panels being fed from the Distribution Board including their designation, location, loading etc.

Each Lighting Panel shall be complete with designation and caution notice plates fixed on front cover and a circuit directory plate fixed on inside of the front cover. Circuit directory plate shall contain details of the points to be controlled by each circuit including the location of the point controlled, rating of the protective units and loading of each circuit.

The plates shall be of anodized aluminium with inscriptions indelibly etched on it.

6.05.07 Bus bar shall be electrolytic grade hard drawn aluminium, colour coded for easy identification and designed for a maximum temperature of 85ºC. Minimum size shall be 25 x 6 mm.

6.05.08 Incoming and outgoing circuits shall be terminated in suitable terminal blocks.

6.06.00 **Board/Panel Equipment**

6.06.01 Each Distribution Board shall consist of one dry type transformer housed in the cubicle, voltmeter with selector switch, C.T. operated ammeter and incoming triple pole MCCB. Outgoing feeder from the Lighting Distribution

Board shall have MCCB. Proper discrimination between outgoing MCCB of Lighting Distribution Board and downstream MCCB of Lighting Panel should be ensured.

6.06.02 Each lighting panel shall have an incoming triple pole MCCB with neutral link and ELCB and a number of outgoing miniature circuit breakers (MCB) as per annexure.

6.06.03 Board/Panel access door shall be interlocked with incoming MCCB such that the door can be opened only when the MCCB is in OFF position. Means shall be provided to defeat this interlock.

6.06.04 All MCCB shall be single throw, air break, heavy duty type having quick-make quick-break contacts. Fuses shall be HRC link type. Contactors shall be air break electromagnetic type. Push buttons shall be push to actuate type.

6.06.05 MCB shall be suitable for manual closing and opening and also automatic trip on overload and short circuit.

6.06.06 Time switch in street lighting panels shall be clock switch type with ON-OFF time setting facility, which shall ensure respective ON-OFF operation in every 24 Hours cycle. Voltmeter/Ammeter shall be of accuracy class 1.0 or better as per IS: 1248. Voltmeter/Ammeter selector switch shall be of reputed make.

6.07.00 **Receptacles**

6.07.01 Receptacles shall be heavy duty, complete with individual plug and switch as detailed in the annexure.

6.07.02 The conduit box of the receptacle shall be provided with earthing screws with washer and nuts welded on the surface for grounding with 16 SWG G.I. wire. Arrangement shall be provided inside the conduit box for grounding of third pin.

6.07.03 Shrouded type plug shall be provided with corresponding matching arrangement at sockets to prevent accidental contact with finger during plug insertion.

6.08.00 **Fans & Regulators**

6.08.01 The fans shall have three well balanced blades, and shall be reasonably free from noise. Pedestal fans shall also be provided as per requirement.

6.08.02 Fan motor shall be totally enclosed type with copper winding and class E insulation.

6.08.03 Regulator shall have minimum five steps. Electronic regulator with smooth control is to be provided.

6.09.00 **Switch & Switch Board**

6.09.01 All switch boards/boxes shall be of bent steel construction, fabricated of 14 SWG M.S. sheet with 6 mm thick bakelite cover with brass fixing screws.

6.09.02 Switch boards/boxes located in control room and office areas shall be flush mounted type on brick wall with only the switch knob projecting outside.

6.09.03 Switch boards/boxes shall have conduit knock outs on the sides. Adequate provision shall be made for ventilation of these boxes.

6.09.04 Flush type receptacles where provided shall be so located that only the plug projects outside.

6.09.05 Switches shall have quick-make and quick-break mechanism operated by a suitable external handle complete with position indicator.

6.10.00 **Lighting Poles & Flood Light Tower**

6.10.01 Street Light Poles

a) Street light poles shall be swaged and welded steel pole, complete with fixing brackets, weather-proof junction box and all other accessories.

b) The pole shall be coated with bituminous preservative paint on inside as well as embedded outside surface. Exposed surface shall be coated with two coats of metal primer (comprising of red oxide and zinc chromate in synthetic medium).

6.10.02 **Flood Light Tower**

a) Flood light tower shall be a lattice structure with maintenance platform and approach ladder. All structural members and hardware shall be hot-dip galvanized.

b) Structures shall be designed for an additional load of 1500kg for maintenance crew. Deflection under maximum wind pressure shall not exceed 1 in 360. Structural design shall be as per IS-800.

6.10.03 **Lighting High Masts**

Applicable standards :

The following shall be Reference Standards for loading of the High Mast:

a)	IS-875 (Part-III) 1987	-	Code and practice for design loads for Structures.
b)	BSEN 10025/DIN 17100	-	Grade of M.S. Plates.
c)	BS-5135/AWS	-	Welding
d)	BS.ISO 1461	-	Galvanizing
e)	TR. No. 7200 of ILE	-	UK Specification for Mast and foundation.

Structure :

Lighting High Mast shall be of continuously tapered polygonal cross section, at least 20 sided, hot dip galvanized and presenting a good and pleasuring appearance and shall be based on proven In-Tension design confirming to

the standards referred to above, to give an assured performance, and reliable service. The structure shall be suitable for wind loading as per IS-875 Part-III, 1987. The masts dimensions shall be as per standards.

The Mast shall be of 30M height with lantern carriage to enable raising/lowering for ease of maintenance, including the Head Frame, Double Drum Winch, continuous stainless steel wire rope, in built power tool, luminaries, suitable aviation warning light, lightning along with necessary power cables within the mast. The mast shall be delivered only in three sections & shall be joined together by slip stressed fit method at site. No site welding or bolted joints shall be done on the mast.

High mast shall be complete with feeder pillar panel for power distribution to lighting fixtures and winch motor. Feeder pillar panel shall be outdoor type stand mounting with dust and vermin proof, IP 55 and constructed of 14 swg sheet steel.

6.11.00 **Maintenance Equipment**

6.11.01 The Contractor shall supply one (1) no. of wheel mounted adjustable aluminium ladder for the maintenance of street lights.

6.11.02 For the maintenance of lighting fixtures within the power house, the contractor shall also supply four (4) nos. free standing adjustable aluminium ladder, adjustable from 5m. to 10m.

6.11.03 For the maintenance of lighting fixtures within the CHP area, the Bidder shall supply two (2) nos. free standing adjustable aluminium ladder, adjustable from 5m. to 10m.

6.12.00 **Special Requirement**

6.12.01 All outdoor illumination fixtures, unless it is fed from photo cell/time switch controlled lighting panel, has to be provided with outdoor type local switches.

6.12.02 In all the air filtration units and air handling units, one marine type lamp (of 100 Watt approx.) shall be supplied and the wiring & fixing of the same has to

6.13.00 **Lighting Cables & Wires**

6.13.01 Lighting Cable shall be heavy duty, 1100 Volt grade, multi-core stranded aluminium conductor, XLPE insulated, extruded PVC inner sheath, single round G.I. wire armoured and overall PVC sheathed with FRLS conforming to IS 1554.

6.13.02 Lighting wires shall be 1100 Volt grade, fire resistance PVC insulated, stranded conductor, single core cable conforming to IS 694, colour coded as below :

RED	for	R-Phase	BLACK	for	Neutral
YELLOW	for	Y-Phase	WHITE	for	+'Ve D.C.

BLUE for B-Phase GREY for -'Ve D.C.

6.13.03 Wire size shall be as follows :

For point wiring beyond lighting panel i.e from lighting Panel to junction box (main run)	:	10 Sq.mm. Aluminium. Stranded conductor
From Junction box to lighting fixture	:	2.5 Sq.mm. Copper Stranded conductor

6.14.00 **Conduits and Accessories**

6.14.01 Conduits shall be rigid steel, hot-dip galvanised, furnished in standard length of 3 metres, threaded at both ends.

6.14.02 Thickness of conduits up to and including 25 mm dia shall be of 16 SWG and conduits above 25 mm shall be of 14 SWG. Minimum size of conduits shall be 20 mm.

6.14.03 Each piece of conduit shall be straight, free from blister and other defects and covered with capped bushings at both ends.

6.14.04 Flexible conduits shall be made with bright, cold rolled annealed and electro-galvanised mild steel strips and coated with PVC.

6.15.00 **Junction Box**

6.15.01 Junction boxes shall be of 16 SWG sheet steel hot-dip galvanised, dust and damp proof, generally conforming to IP-55.

6.15.02 Junction boxes shall be complete with gasketed inspection cover, conduit knock out/threaded hub and terminal blocks.

6.15.03 Junction boxes for outdoor use shall be weatherproof IPW-55 and those for hazardous location shall be flame-proof type.

6.15.04 Junction boxes shall have following indelible markings:

Circuit nos. on top

Circuit nos. with ferrules (inside) as per drawing

DANGER sign in case of 415V circuit

6.16.00 **Terminals**

6.16.01 Multi way terminal blocks of approved type, complete with screws, nuts, washers and marking strips shall be furnished for connection of incoming/outgoing wires.

6.16.02 Each terminal shall be suitable for connection up to 2 nos. 10 Sq.mm stranded aluminium conductors without any damage to the conductor or looseness of connectors.

6.17.00 **Portable Emergency Lighting Unit**

The portable emergency lighting unit shall be complete with 6 volt storage battery (rechargeable), inverter, automatic charger, twin 6 watts fluorescents tube lamp and test switch. Contractor shall furnish make, type and catalogue.

6.18.00 **24 V Supply Module**

6.18.01 Each 24V A.C. supply module shall have one (1) no air cooled two winding, 500VA, 1-phase, 50Hz, 240/24V transformer with 6A (240V side) and 16A (24V side) HRC fuse and necessary 240V and 24V terminals for incoming and outgoing connections. The 240V terminals of 24V AC supply module shall be fed from respective lighting panels. A group of 6A, 24V AC receptacles located near Boiler access doors and condenser area shall be wired up from 24V side of each 24V A.C. supply module.

The 24V A.C. supply modules shall be sheet steel enclosed with louvers and shall be suitable for outdoor use. The 24V A.C. supply modules shall be suitable for wall/steel structure/column mounting. Switches shall be mounted at the front on sheet steel enclosure.

6.18.01 Portable 24 V AC supply modules having sheet steel enclosure with louvers as per above shall be supplied. 24V halogen automobiles lamps with reflector along with 1100 V, twin core PVC sheathed, 2.5 mm^2 stranded copper wire of 20 m lengths as handset

Exact requirement will be finalized during detail engineering and accordingly the bidder shall furnish the same.

6.19.00 **Not used.**

6.20.00 **Moulded Case Circuit Breaker (MCCB**)

6.20.01 MCCB shall be heavy duty, triple pole, load break-fault-make type conform to the duty as required. MCCB shall be provided with a common trip bar, so as to ensure opening of all phases even when fault occurs in only one phase.

6.20.02 MCCB shall have positive indication in ON and OFF position with indication on each Module.

6.20.03 The MCCB should be housed in a heat resistant moulded insulated housing Overload and Magnetic release of MCCB shall be suitable for setting at site. The Short Circuit release shall be of minimum of 12x In.

6.20.04 For Fuel Oil / hazardous area, one (1) no. 63Amp MCB shall be provided within a Flame-proof enclosure. The enclosure shall be Flame-proof as per the stipulations of relevant standard. It shall have a degree of protection of IPW-55. The enclosure front access door shall be interlocked with the MCB. It shall have grounding facility on opposite sides complete with designation and caution notice plates fixed on the front cover. It shall meet the requirement of IS 5571 & IS – 5572.The MCB enclosure shall suitable for entry of 4/Cx16 sq.mm XLPE Copper cable. The total unit shall have a valid certification for using in the specified zone from statuory authority preferably of CMRI and/or CE Ex II 2 G EEx-D IIB T4/T5/T6; CE Ex II2 2(1) G EEx-d (ia) IIB T5/T6; CE Ex II2 (1) GD EEx-d (ia)IIB T5/T6 or similar.

6.21.00 **Nameplate**

Nameplates shall be furnished for identification of devices and circuits. All switches, controls and indications shall be permanently and legibly marked in English as to clearly indicate their functions.

All lighting fixtures, receptacles, fans, junction boxes etc. shall be properly marked up indelibly with corresponding circuit numbers.

6.22.00 **Samples**

Owner reserves the right to call for samples if considered necessary and the same shall be submitted by the Bidder free and without any obligation.

6.23.00 **Street light powered by solar energy**

Solar PV street lighting system is an innovative system that operates using the light energy available from the sun to provide lighting during nighttime. This system is based on the principle of conversion of solar energy into DC electricity.

Solar PV street lighting is a reliable and an efficient stand alone system. It presents a package consists of a solar PV module, a lead acid battery, battery charger regulator & dusk to dawn regulator, electronics control unit complete with high frequency inverter and luminaire.

The energy radiated by sun is converted to DC power by the adjustable solar PV module mounted on the top of the lighting pole. This power is stored in the battery housed in the battery box and powers the street light during the night. The system is automatically switched on at dusk and off at dawn.

Basic system components as per MNES specification are

- Solar PV module (12V, 75Wp)
- A hot deep galvanized epoxy coated light pole with module frame structure
- Luminaries using CFL 11W lamp with high efficiency inverter and dusk to dawn regulator circuit. Along with water proof cabinet.
- A low maintenance 12V, 75AH tubular stationary lead acid battery specially designed for photovoltaic application with suitable battery box.
- A complete set of cables and other installation material.

It shall be featured with bright light, 3/5 non-sun days autonomy, auto on/off and integrated design.

7.00.00 **SPECIFIC REQUIREMENTS - SERVICES**

7.01.00 **Consumables and Hardware**

7.01.01 The Contractor shall furnish all erection materials, hardware and consumables required for the complete installation.

7.01.02 The materials shall include but shall not be limited to the following :

a) Consumables : Welding rods & gas, oil and grease, cleaning fluids, paints, electrical tape, soldering materials etc.

b) Hardware : Bolts, nuts, washers, screws, brackets, supports, clamps, hangers, saddles, cleats, sills, shims etc.

c) Materials : Junction boxes, terminal blocks, connectors, ferrules, lugs, brass glands, rigid/flexible conduits, cables, ground wires etc.

7.01.03 Supply of cement, sand, stone etc. required for the execution of the contract shall be the responsibility of the Contractor.

7.02.00 **Testing Equipment**

7.02.01 The Contractor will provide such checking and testing equipment as test lamp, buzzer, 500-volt meggar, earth meggar, lux-meter etc. and also other testing equipment as required.

7.03.00 **Installation - General**

7.03.01 Installation work shall be carried out in accordance with good engineering practices and also manufacturer's instructions/ recommendations where the same are available.

7.03.02 Equipment shall be installed in a neat workmanlike manner so that it is level, plumb, square and properly aligned and oriented.

7.04.00 **Lighting Fixtures**

7.04.01 Continuous rows of fluorescent tubes shall be mounted on a continuous M.S. angle for each row of lights.

7.04.02 In turbine hall, fixtures shall be mounted to maintain sufficient clearance from the overhead traveling crane trolley.

7.04.03 In boiler galleries, mounting height of fixtures shall be about 2500 mm from platforms except shown otherwise.

Bracket for fixture mounting shall be fabricated at site from 40 mm conduits with a reducing socket to suit the fixtures and clamped on to the handrails. The fixing shall be strong enough to withstand vibration and high wind velocity.

If a roof over platform is available, the fixture can be pendant mounted.

7.04.04 Floodlights shall be mounted on steel base facing the tentative direction shown on drawings. Fixing holes shall be provided with slot to turn the fixture

about 5 Deg on both sides. Bolts shall be finally tightened with spring washer.

The Contractor shall supply and install the steel base for fixing the flood light on the flood light towers.

Terminal connection to the floodlight shall be made through PVC coated flexible metallic conduits.

7.04.05 Fixtures shall be mounted on sub-station structures with suitable clamps. No cutting or drilling of sub-station structures is permitted.

7.04.06 The fixtures after erection shall be marked up indelibly with corresponding circuit number for easy identification of lamp circuit.

7.05.00 **Receptacles**

Receptacles shall be installed at locations shown in approved drawings. As a minimum the following shall be provided –

Atleast one 6/16A, 240V AC universal socket outlet with switch shall be provided in office, cabins, etc.

63A, 3 phase, 4 wire, 5 pin Receptacle shall be provided at the following locations as a minimum –

a) Two (2) nos. at each floor of TG building
b) Three (3) nos. in each Boiler platform
c) One (1) each in pump houses and switchgear rooms
d) One (1) no. in each ESP, Transformer yard, Cooling Tower, Battery room.
e) Two (2) nos. in each floor of Junction Tower, Transfer Tower, Screen house, Bunker floor, Hopper area, CHP switchgear room. Receptacles in these area will be flame proof type.
f) In conveyor gallery Receptacle shall be provided at interval of 50m, atleast one if length is less than 50m.

Each circuit of welding DB shall feed a maximum of two (2) nos. welding receptacles.

7.06.00 **MLDB, EMLDB DCELDB and Lighting Panel**

7.06.01 MLDB, EMLDB DCELDB and Lighting panels shall be erected at the locations indicated in approved drawings.

7.07.00 **Street Lighting Poles**

Erection of Street Lighting poles together with all its accessories including civil foundation work, installing lighting fixture, wiring and cabling work are included within scope of contractor.

7.08.00 **Conduit System**

7.08.01 In case of unarmoured cable, all conduits shall originate from the respective lighting panel and terminate in lighting fixtures, receptacles etc.

7.08.02 Exposed conduits shall be run in straight lines parallel to building columns, beams and walls as far as practicable. Unnecessary bends and crossings shall be avoided to present a neat appearance.

7.08.03 Conduit supports shall be provided at an interval of 750 mm for horizontal runs and 1000 mm for vertical runs.

7.08.04 Conduits shall be clamped on to approved type spacer plates or brackets by saddles or U-bolts. The spacer plates or brackets in turn, shall be fixed to the building steel by welding and to concrete or brick work by grouting as shown on drawings.

Wooden plug inserted in the masonry or concrete for conduit support is not acceptable.

7.08.05 Embedded conduits shall be securely fixed in position to preclude any movement. In fixing embedded conduit, if welding or brazing is used, extreme care should be taken to avoid any injury to the inner surface of the conduit.

7.08.06 Spacing of embedded conduits shall be such as to permit flow of concrete between them and in no case shall be less than 40 mm.

7.08.07 Where conduits are run on cable trays they shall be clamped to supporting steel at an interval of 600 mm.

7.08.08 For directly embedding in soil, the conduits shall be coated with an asphalt - base compound. Concrete pier or anchor shall be provided where necessary to support the conduit rigidly and to hold it in place.

7.08.09 Conduits shall be installed in such a way as to ensure against trouble from trapped condensation.

7.08.10 Running threads shall be avoided as far as practicable. Where it is unavoidable, check nuts shall be used.

7.08.11 Conduits shall be kept, wherever possible, at least 300 mm away from hot pipes, heating device etc. when it is evident that such proximity may impair the service life of cables.

7.08.12 Slip joints shall be provided when conduits cross structural expansion joints or where long run of exposed conduits are installed, so that temperature change will cause no distortion due to expansion or contraction of conduit run.

7.08.13 For long run, junction/pull boxes shall be provided at suitable intervals to facilitate wiring.

7.08.14 Conduits shall be securely fastened to junction box or cabinets, each with a locknut and insulated bushing inside the box and locknut outside.

7.08.15 Conduit lengths shall be joined by screwed couplers. Couplers shall be clearly cut.

7.08.16 Conduit joints and connections shall be made thoroughly water-tight and rust-proof by application of a thread compound which will not insulate the joints.

White lead is suitable for application on embedded conduit and red lead for exposed conduit.

7.08.17 The Battery Room installation shall be made with acid fume proof conduits.

7.08.18 Field bends shall have a minimum radius of four (4) times the conduit diameter. All bends shall be free of kinks, indentations or flattened surfaces. Heat shall not be applied in making any conduit bend.

7.08.19 The entire metallic conduit system, whether embedded or exposed, shall be electrically continuous and thoroughly grounded.

7.08.20 Lighting fixture shall not be suspended directly from junction box in the main conduit run.

7.08.21 Conduits and fittings shall be properly protected during construction period against mechanical injury. Conduits ends shall be plugged or capped to prevent entry of foreign material.

7.08.22 After installation the conduits shall be thoroughly cleaned by compressed air before pulling in the wire.

7.08.23 In control rooms and office areas provided with false ceiling conduct run shall be concealed type, embedded in the walls.

7.09.00 **Wiring**

7.09.01 Wiring shall be generally carried out by PVC wires in conduits. All wires in a conduit shall be drawn simultaneously. No subsequent drawing is permissible.

7.09.02 Wire shall not be pulled through more than two equivalent 90º bends in a single conduit run.

7.09.03 Wiring shall be spliced only at junction boxes with approved type connections or terminal strips. Maximum two wires can be connected to each way of the terminal block. Splicing of only one phase shall be done in a junction box.

7.09.04 For lighting fixtures, connection shall be teed off through suitable round conduit or junction box, so that the connection can be attended without taking down the fixture.

7.09.05 For vertical run of wires in conduit, wires shall be suitably supported by means of wooden/hard rubber plugs at each pull/ junction box.

7.09.06 A.C. and D.C. circuits shall not be run in the same conduit and junction boxes. Circuits fed from different transformers shall be run through different conduits and Junction boxes.

7.09.07 Receptacle circuits shall be kept separate and distinct from lighting and fan circuits.

7.09.08 Separate neutral wire shall be provided for each circuit. Wiring throughout the installation shall be such that there is no break in the neutral wire in form of switch or fuse.

7.10.00 **Cabling**

7.10.01 In outdoor areas, main runs from lighting panels shall be by means of XLPE cables, directly buried in ground or laid in trenches for the underground portion and through conduit for the over ground portion.

7.10.02 Buried cables shall be laid and covered with sand/ riddled earth, and protected from damage by bricks at sides and pre cast concrete stab at top. Buried cables shall have cable markers at 50M interval and projecting 150 mm above ground. At cable bends and joints markers shall be provided.

7.10.03 When buried cables cross road/railway track, additional protection to be provided in form of hume / G.I. pipe.

7.11.00 **Grounding**

7.11.01 All lighting panels, junction boxes, receptacles, fixtures, conduit etc. shall be grounded in compliance with the provision of I.E. Rules.

7.11.02 Ground connections shall be made from nearest available station ground grid. All connections to ground grid shall be done by arc welding.

7.11.03 Panels/Boards shall be directly connected to ground grid by two nos. 35 x 6 mm G.I. flats (for panels) / two nos. 50x6 mm G.I. flats (for distribution boards).

7.11.04 All junction boxes, receptacles, lighting fixtures etc. shall be grounded with 16 SWG G.I. wire.

7.11.05 Each street lighting Pole shall be grounded at two points by two nos. 50x6 mm G.I flat risers from two (2) nos. earthing spike 40 mm dia & 3m long directly driven into ground at a depth of 1m from ground level. The junction box at each lighting pole is grounded at two (2) points from two (2) nos. earthing terminals by 16 SWG GI wire. One 16 SWG G.I wire shall be taken up to the junction box from lighting fixtures and connected to grounding point.

7.12.00 **Foundation & Civil Works**

7.12.01 Equipment foundations, panel foundations and all other civil work will be provided by the Contractor.

7.13.00 **Excavation and Back Filling**

7.13.01 The Contractor shall perform all excavation and backfilling as required for buried cable and ground connections.

7.13.02 Excavation shall be performed up to the required depth. Such sheeting and shorting shall be done as may be necessary for protection of the work.

7.13.03 The Contractor shall make use of his own arrangements for pumping out any water that may be accumulated in the excavation.

7.13.04 All excavation shall be backfilled to the original level with good consolidation.

7.14.00 **Steel Fabrication**

7.14.01 All supports, hangers & brackets shall be fabricated by the Contractor. Necessary steel shall be supplied by the Contractor.

7.14.02 Steel for fabrication shall be straightened and cleaned of rust and grease. All fabrication shall be free of sharp edge.

7.14.03 Every effort shall be made to minimize the wastage of steel as far as practicable during fabrication. The wastage in no case shall exceed 3% of the total quantity of steel fabricated.

7.15.00 **Painting**

7.15.01 Street light poles shall be given two coats of aluminium paints after installation.

7.15.02 All steel fabrication shall be given two coats of red oxide primer. Finish paint shall be as mentioned in clause no.1.16.00 of Section-I, Volume V-A..

7.15.03 All equipment shall be given touch-up paint as required after installation.

7.16.00 **Inspection & Testing**

7.16.01 On completion of erection works, the Contractor shall request the Engineer for inspection and tests with minimum fourteen (14) days advance notice.

7.16.02 The Engineer shall arrange for joint inspection of the installation for completeness and correctness of the work. Any defect pointed out during such inspection shall be promptly rectified by the Contractor.

7.16.03 The installation shall be then tested and commissioned in presence of the Engineer and put on trial run for stipulated contract period.

7.16.04 All rectification, repair or adjustment work found necessary during inspection, testing, commissioning and trial run shall be carried out by the Contractor without any extra cost.

8.00.00 **TESTS**

8.01.00 **Shop Tests**

8.01.01 All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant Indian Standards at manufacturer's works.

8.01.02 Tests on lighting Distribution Boards/Panels shall include :

a) Wiring continuity tests.

b) High voltage and insulation tests.

c) Operational tests.

8.02.00 **Site Tests**

8.02.01 Contractor shall thoroughly test and megger all cables, wires and equipment to prove that the same are free from ground and short circuit.

8.02.02 If any ground or short circuit is found, the fault shall be rectified or the cable and/or equipment replaced.

8.02.03 All equipment shall be demonstrated to operate in accordance with the requirements of this specification.

8.02.04 Illumination in different areas are as per designed lux level should be established.

9.00.00 **DRAWINGS, DATA & MANUALS**

9.01.00 Drawings, data and manuals shall be submitted in triplicate with the bid and in quantities and procedures as specified in the General Condition of Contract and/or elsewhere in this specification for approval and subsequent distribution after the issue of Letter of Intent.

9.02.00 **To be submitted with the Bid**

9.02.01 Make, type and catalogue number of lighting fixtures, lamps and accessories along with technical leaflets, data sheets, polar curves etc.

9.02.02 Typical outline drawings, showing constructional features, cable/ conduit entry, fixing arrangements etc of :

a) Lighting Distribution Board & Panel/receptacles/junction boxes.

b) Street light pole.

9.02.03 Technical leaflets and data sheet on each piece of equipment / device such as MCB, switch fuse, MCCB, receptacle etc.

9.02.04 Type test certificates on lighting fixtures and lighting panels, transformer, ballast, power cables.

9.03.00 **To be submitted after Award of Contract**

9.03.01 All relevant drawings and data pertaining to the lighting system like GTP, GA drawing, BOM, lighting layout drawings showing disposition of fixtures,

panels, conduit/wire routing, schematic drawing, QAP, etc. shall be submitted by the Bidder for the approval of Owner/Owner's consultant. Also refer clause no. 1.19.02(u) of Section-I of Volume – V-A: Technical Specifications for Electrical Equipment & Accessories.

9.03.02 AS-BUILT lighting layout and erection drawings, properly incorporating the changes/alterations/field modifications, if any, as carried out at field along with circuit distribution schemes of all lighting panels, conduit and cable routing and as acceptable to the Owner.

ANNEXURE-A

AVAILABLE POWER SUPPLY

1.0 **System Voltage**

Lighting equipment and accessories shall be designed for satisfactory operation from the following power supply sources:

1.1	A.C. Supply	:	415 Volt, 3 phase, 50 Hz, 4 wire effectively grounded system. Fault Level 50 KA r.m.s. symmetrical.
1.2	D.C. Supply	:	220 V, 2 wire, ungrounded system. Fault Level 25 * KA

2.0 **Permissible Variation**

Equipment and accessories shall be suitable for operation over the entire range of voltage/frequency variations as listed below:

2.1	A.C. Supply	:	Voltage $\pm$ 10% Frequency +3% to -5% Combined Voltage + Frequency 10% (absolute sum)
	D.C. Supply	:	Voltage 187 to 242 Volt.

* Indicative only; actual value will be decided by the Bidder after substantiating the same by calculation.

ANNEXURE-B

TYPES OF LIGHTING EQUIPMENT

1.0 LIGHTING FIXTURES & LAMPS

Each lighting fixture shall be furnished complete with associated lamp, holder and control gear fully wired up. Control should include copper ballast, electronic choke, capacitor starter, electronic-igniter (separate type), fuse connector block etc.

Well glass fittings for HPSV lamps higher wattage (250/400 W) floodlight luminaire, the control gear will be separate/non-integral type whereas for high bay, streetlight and mini flood light fixture, the control gear shall be integral type.

SL. NO.	FIXTURE TYPE	REFERENCE FIXTURE NO.	DESCRIPTION	AREA OF USE
1.1	SA	GE GET CI 1X28 C/S HF + Reflector 1X28 (ALM) / eqv.	Surface / pendant mounted with Al reflector commercial / decorative type luminaire suitable for 1 x 28W T5 FL	Swgr room / MCC room / Workshop / Maint. Shop / Office / Toilet / Corridor / Pantry / Stores
1.2	SB	GE GET CI 1X28 C/S HF / eqv.	Surface / pendant mounted without reflector commercial / decorative type luminaire suitable for 1 x 28W T5 FL	Swgr room / MCC room / Workshop / Maint. Shop / Office / Toilet / Corridor / Stairs / Pantry / Stores
1.3	DA	GE GET CI 2X28 C/S HF + Reflector 2X28 (ALM) / eqv.	Surface / pendant mounted with Al reflector commercial / decorative type luminaire suitable for 2 x 28W T5 FL	Swgr room / MCC room / Workshop / Maint. Shop / Office / Toilet / Corridor / Pantry / Stores
1.4	DB	GE GET CI 2X28 C/S HF / eqv.	Surface / pendant mounted without reflector commercial / decorative type luminaire suitable for 2 x 28W T5 FL	Swgr room / MCC room / Workshop / Maint. Shop / Office / Toilet / Corridor / Stairs / Pantry / Stores
1.5	DC	Philips TCS 150 2XTL5-28W MIEBT 228 / eqv.	Decorative, surface / pendant mounted mirror optics luminaire housing made up of CRCA sheet steel, powder coated white, accommodating all electrical accessories pre-wired up to a terminal block suitable for 2 x 28W TL5.	Office rooms / Corridor / Conference Room / Engineer's Room
1.6	DD	Philips TMS 669 M 2XTL5-28W HF D6 / eqv.	Decorative, recess mounted mirror optics luminaire, housing made up of CRCA sheet steel, powder coated white,	False Ceiling areas (Control Room / Electronic Eqpt. Room / Office / Conference room /

SL. NO.	FIXTURE TYPE	REFERENCE FIXTURE NO.	DESCRIPTION	AREA OF USE
			accommodating all electrical accessories pre-wired up to a terminal block suitable for 2 x 28W TL5.	Engineer's Room / Corridor)
1.7	DE	GE MAR228FTL HF / eqv.	Indoor, industrial, corrosion resistant, with diffuser and reflector for lamp, ceiling or suspension mounting luminaire suitable for 2 x 28W T5 FTL.	Battery Room / Chemical Plant / Area with corrosive atmosphere
1.8	MA	Philips HPK250 1XSON250W E / eqv.	Medium and High bay non integral luminaire with aluminium anodized reflector and toughened glass cover suitable for 1 x 250W HPSV lamp	General Indoor equipment area / Pump House / Workshop
1.9	MB	Philips HPK225 1XSON150W E / eqv.	Medium and High bay integral luminaire with aluminium anodized reflector and toughened glass cover suitable for 1 x 150W HPSV lamp	General Indoor equipment area / Pump House / Workshop
1.10	MC / MD	Philips HPK225 1XSON250W /400W E / eqv.	Medium and High bay integral luminaire with aluminium anodized reflector and toughened glass cover suitable for 1 x 250W/400W HPSV lamp	General Indoor equipment area / TG Hall / Pump House
1.11	LA / LB	Philips HPK 150 1XSON-I 70W / eqv.	Integral, higher ingress protection, pressure die-cast Aluminium housing, well glass, luminaire with built in control gear suitable for 1 x 70W HPSV lamp	Boiler Platform / ESP Platform / Dust & Vapour laden areas
1.12	JA/JB	Bajaj BJFW-125MV / eqv.	Flamefroof, weatherproof, non-integral wellglass luminaire for indoor / outdoor applications suitable for 1 x 125W MV lamp	Fuel Oil Pump House / Area with explosive atmosphere
1.13	IA	Philips NXC101 1xA60-60W-CL B22 GR/ eqv.	Weatherproof bulkhead luminaire suitable for 1 x 60W GLS lamp.	DC emergency lighting / staircase / exit point
1.14	NA	Philips TRC033 2XTL-D36W IC / eqv.	Road lighting luminaire, Aluminium steel housing, gear tray cum reflector	Building exterior lighting / Outdoor area lighting /

SL. NO.	FIXTURE TYPE	REFERENCE FIXTURE NO.	DESCRIPTION	AREA OF USE
			made of CRCA sheet, with acrylic cover suitable for 2X36W TL-D.	Outdoor eqpt. Area
1.15	TA	Philips SGP 325 1XSON-T 150W FG / eqv.	Street light luminaire with pressure die cast aluminium housing, POT optics reflector and heat resistant toughened flat glass cover (IP 65) with 1 x 150W HPSV lamp - pole mounted	Street lighting / boundary lighting
1.16	TB	Philips SGP 325 1XSON-T 250W FG / eqv.	Street light luminaire with pressure die cast aluminium housing, POT optics reflector and heat resistant toughened flat glass cover (IP 65) with 1 x 250W HPSV lamp - pole mounted	Street lighting / boundary lighting
1.17	CA	Bajaj BJC-111 / eqv.	Surface mounting decorative luminaire with 1 x 11W CFL	Toilet / Wash basin / staircase
1.18	CB	Philips FCS 100 1XPL-C/2P 18W I 240V / eqv.	Surface mounting decorative downlight luminaire, electrochemical brightened reflector with 1 x 18W PL-C	Lobby / Staircase
1.19	CC	Philips FBH 145 M 1XPL-C/2P 18W / 220V / eqv.	Recess, decorative vertical mounting downlighter, high efficiency optics and option of multiple attachment suitable for 1X 13W/18W PL-C	Control Room / Electronic Eqpt. Room for DC emergency light
1.20	CD	Philips FBH 145 M 2XPL-C/4P 18W HF 240V LH / eqv.	Recess, decorative vertical mounting downlighter, high efficiency optics and option of multiple attachment suitable for 2X 18W PL-C	Control Room / Electronic Eqpt. Room / Conference room / Office / Engineer's Room as UPS emergency light
1.21	PA	Philips SWF231 1XSON-T 150W A / eqv.	Compact, sturdy, general purpose with integral gear floodlight luminaire suitable for with 1 x 150W HPSV lamp	Area lighting / Yard lighting / Floodlighting purpose
1.22	PB	Philips SWF331 1XSON-T 250W	Compact, sturdy, general purpose with integral	Area lighting / Yard lighting /

SL. NO.	FIXTURE TYPE	REFERENCE FIXTURE NO.	DESCRIPTION	AREA OF USE
		A / eqv.	gear floodlight luminaire suitable for with 1 x 250W HPSV lamp	Floodlighting purpose
1.23	PC	Philips RVP302 2XSON-T 250W / eqv.	Compact, sturdy non integral, corrosion resistant with pre anodized aluminium reflector, floodlight luminaire suitable for with 2 x 250W HPSV lamp	Area lighting / Yard lighting / Floodlighting purpose
1.24	PD	Philips RVP302 2XSON-T 400W / eqv.	Compact, sturdy non integral, corrosion resistant with pre anodized aluminium reflector, floodlight luminaire suitable for with 2 x 400W HPSV lamp	Area lighting / Yard lighting / Floodlighting purpose
1.25	BA	Philips SWF231 1XMHN-TD 150W A / eqv.	Compact, sturdy, general purpose with integral gear floodlight luminaire suitable for with 1 x 150W metal halide lamp	Area lighting / Yard lighting / Floodlighting purpose
1.26	BB	Philips SWF331 1XMHN-TD 250W A / eqv.	Compact, sturdy, general purpose with integral gear floodlight luminaire suitable for with 1 x 250W metal halide lamp	Area lighting / Yard lighting / Floodlighting purpose
1.27	BC	Philips RVP302 2XMHN-TD 250W / eqv.	Compact, sturdy non integral, corrosion resistant with pre anodized aluminium reflector, floodlight luminaire suitable for with 2 x 250W metal halide lamp	Area lighting / Yard lighting / Floodlighting purpose
1.28	BD	Philips RVP302 2XMHN-TD 400W / eqv.	Compact, sturdy non integral, corrosion resistant with pre anodized aluminium reflector, floodlight luminaire suitable for with 2 x 400W metal halide lamp	Area lighting / Yard lighting / Floodlighting purpose
1.29	EX	Philips (Exit Lamp) / eqv.	Escape lighting luminaire with “EXIT” sign fitted with 1x20 FLT. Each luminaire shall be self contained 6 volt battery, battery charger unit.	Control Room / Electronic Eqpt. Room / Conference room / Office / Engineer's Room as UPS

SL. NO.	FIXTURE TYPE	REFERENCE FIXTURE NO.	DESCRIPTION	AREA OF USE
			Normally the luminaire shall be ON continuously through 240V AC supply. When AC supply goes OFF the in built battery & inverter system automatically takes on to ignite luminaire for duration of two & half (2½) hours. The battery shall be maintenance free and shall be trickle charged when 240 V AC mains supply is available.	
1.30	FA	GE Evolve™ LED Outdoor Family IBERIA / eqv..	Die-cast aluminium housing, decorative luminaire using LED technology with symmetric and asymmetric light distribution, IP 65 rated for optical assembly with high brightness LED-pole mounted.	Street lighting / boundary lighting
1.31	Ceiling/Column /wall mounted	Bajaj BJDB 100 with 1X100W. GLS/eqv	Bulkhead luminaire with wire guard, die cast Al alloy body, heat resistant prismatic glass cover with specially designed weather proof gasket.	Emergency light-ing in CHP area

Note 1: The supply also includes associated junction boxes, brackets, supports, hangers, and wires wherever applicable.

2.0 LIGHTING PANEL

2.1	LP-1	415 V A.C. Indoor type Lighting Panel with 415 V, 100A, 3 ph, 4 wire bus, one (1) no. 100A TP & N switch/MCCB as incomer along with ELCB, 24 nos. 20A, 240 V, 1 pole MCBs as outgoing feeders.
2.2	LP-2	415 V A.C. Indoor type Lighting Panel with 415 V, 100A, 3 ph, 4 wire bus, one (1) no. 100A TP & N switch/MCCB as incomer along with ELCB, 18 nos. 20A, 240 V, 1 pole MCBs as outgoing feeders.
2.3	LP-3	415 V A.C. Indoor Lighting panel with 415 V, 3ph, 4W bus & one 63A TP & N Switch/MCCB as incomer with ELCB and 12 nos 20A , 240V 1 pole MCBs as outgoing feeder.
2.4	LP-4	415V A.C. Indoor type Lighting Panel with 415V, 63A, 3 ph, 4 wire bus, one (1) no. 32 A TP & N switch/MCCB as incomer with ELCB, 6 nos. 20A, 240V, 1 pole MCBs as outgoing feeders.

2.5	SLP	415 V A.C. Outdoor type Panel with 415 V, 100A, 3 ph, 4 wire bus, one 100A TP & N switch/MCCB as incomer, 18 nos. 20A, 240V, 1 pole MCBs as outgoing feeders. The lighting panel shall be provided with 63A contactor, frequency compensated timer switch, photo-cell switch push- buttons for automatic control of street/area lighting with provision for manual override.
2.6	DCLP	Indoor type emergency lighting panel with 240V bus, one no Fuse switch as incomer and 6 nos 16A two pole MCB as outgoing feeders.
2.7	FLP	Outdoor, lockable type Isolating switch of 415V, 63A, 3 ph, 4 wire TP & N. with 2 mm sheet steel/cast iron cubicle.
3.0	**RECEPTACLE**	
3.1	RA	6A, 240 V, 2 pole, 3 pin with third pin earthed, suitable for flush mounting in office areas and control room. The switch shall be also flush mounted piano type.
3.2	RB	16A, 240V, 2 pole, 3 pin with third pin earthed, wall/ column mounted, metal clad gasketed construction, 20mm conduit entry, screwed metal cover tied to it by a metal chain, weatherproof suitable for indoor/outdoor installation.
3.3	RC	63A, 415 V, 3 phase, 4 pin interlocked plug and switch with earthing contact, wall/column mounted, metal clad gasketed construction, weatherproof, suitable for loop-in/loop-out connection of 4/C-35 Sq.mm XLPE cable. These shall be fed from Welding DB.
3.4	RD	125 A, 415 V, 3 phase 5 pin interlocked plug & switch with fifth pin earthed, wall/column mounted metal clad gasketed construction, weatherproof, suitable for loop in and loop out connection of 3-1/2C -95 Sq.mm XLPE cable. These shall be fed from A.C-Distribution Board/Station MCC.
4.0	**CEILING FANS**	
4.1	FA	1200 mm sweep ceiling fan with regulator, down rod and canopy.
4.2	FB	1400 mm sweep ceiling fan with regulator, down rod and canopy.
5.0	**LIGHTING POLES**	
5.1	TA/TB	Single arm/double arm swaged and welded steel pole with junction box and all accessories.
6.0	**SWITCHBOARD**	
6.1	S-1	Switch board with 1-6A switch.
6.2	S-2	Switch board with 3-6A switch and 1-6A receptacle.
6.3	S-3	Switch board with 6-6A switch and 1-6A receptacle.
7.0	**MISCELLANEOUS ITEMS**	
7.1	M1	10 m high car wheel mounted aluminium ladder.
7.2	M2	Adjustable free-standing aluminium ladder height adjustable from 5 m to 10 m.+
7.3	M3	Portable Emergency light set complete with one 20W tube light, battery, battery charger and all other accessories.
7.4	M4	24 Volt Supply Module with all accessories.

ANNEXURE-C

ILLUMINATION LEVEL & AREA WISE LIGHT DISTRIBUTION

Sr. No.	Area/Structure	Average Illumination Level in Lux.	Type of Fixture / Luminaire	Type of Lamp
1.0	**Turbine Generator Building :**			
1.1	General Auxiliary Equipment Areas	100	Industrial Well Glass	70W/150W HPSV/125 W HPMV Lamp
1.2	Cable Spreader Room	70	Industrial type fluorescent lamp with vitreous enamel reflectors	Fluorescent tube (T5) with electronic ballast.
1.3	Switchgear Room	200	Industrial type fluorescent lamp with vitreous enamel reflectors	Fluorescent tube (T5) with electronic ballast.
1.4	TG Building Operating Floor	200	Industrial Integral high bay	250 W/400W HPSV / HPMV lamp
1.5	Main Control Rooms	400	Decorative recessed mounted with mirror optics aluminum anodized reflector	2 x 28W FTL
1.6	Battery Rooms	200	Industrial Corrosion proof luminarie.	2 x 28W FTL.
1.7	Unloading and Maintenance bay	250	Industrial integral high bay	250 W / 400W HPSV /HPMV lamp
2.0	**Boiler Area :**			
2.1	Boiler area and platforms	100	Dust proof / dust tight integral well glass luminaire	70 W HPSV/ 125W HPMV lamp
2.2	Coal Bunker and Mill bay area	100	Dust proof / dust tight integral well glass luminaire	1 x 80 W /125 W HPMV lamp
2.3	ESP areas and Platforms	100	Dust proof / dust tight integral well glass luminaire	70 W HPSV/ 125W HPMV lamp
2.4	ESP Control Room	400	Decorative recessed mounted with mirror optics aluminum anodized reflector	2 x 28 W FTL.
3,0	**Transformer Yard :**			
3.1	General	20	General purpose flood light	250 W/400 W HPSV lamp
3.2	Near equipment	50	Dust proof / dust tight integral well glass	1 x 70 W HPSV lamp
4.0	**Laboratory**			

Sr. No.	Area/Structure	Average Illumination Level in Lux.	Type of Fixture / Luminaire	Type of Lamp
4.1	General	100	Decorative recess / surface mounted/ Suspended type mirror optics	Fluorescent tube (T5) with electronic ballast.
4.2	Analysis Area	300	Industrial Corrosion proof luminarie.	2 x 28W FTL.
5.0	**Various Off-site Buildings :**			
5.1	Equipment Room / Switchgear Rooms	200	Industrial type fluores-cent lamp with vitreous enamel reflectors up to mounting height of 3.5 M or Industrial medium bay integral luminaire for mounting heights between 3.5 to 8 M.	fluorescent tube (T5) with electronic ballast
5.2	Pump Houses/ DG room / Compressor room	200	Industrial well glass / Industrial Medium bay integral luminaire	70 W HPSV/ 150W HPSV lamp
5.3	DM Plant, Pre-Treatment	150	Industrial trough type fluorescent/ Industrial Medium bay integral luminaire	2 x 28W FTL. / 125W HPMV / 150W HPSV lamp
5.4	Workshop	150	Industrial trough type fluorescent/ Industrial Medium bay integral luminaire	2 x 28W FTL. / 125W HPMV / 150W HPSV lamp
6.0	**Cooling Water Pump House Area :**			
6.1	Cooling Tower Area	30	Industrial well glass	70 W HPSV/ 125W HPMV lamp
6.2	CW PH	200	Industrial medium bay integral luminaire for mounting heights between 3.5 to 8 M	70 /150 W HPSV or 150 / 250 W HPMV lamp
7.0	**Road & Yard Lighting:**			
7.1	Main Roads	20	Integral type street Lighting luminaire with aluminium reflector	150 /250W HPSV lamp
7.2	Secondary Roads	10	-do-	-do-
7.3	Perimeter (Compound) Lighting	10	-do-	-do-
8.0	**Service Building, Canteen, etc.**			
8.1	Main Office /Staff Room	300	Decorative recess mounted mirror optics aluminum anodized reflector	2 x 28W FTL
8.2	Non-Office /Service	300	Decorative recess /	Fluorescent tube

Sr. No.	Area/Structure	Average Illumination Level in Lux.	Type of Fixture / Luminaire	Type of Lamp
	Areas		surface mounted/ Suspended type mirror optics	(T5) with electronic ballast.
9.0	**General :**			
9.1	Corridors, Walkways, Staircase, Lockers etc.	70	Industrial type fluorescent lamp with vitreous enamel reflectors	Fluorescent tube (T5) with electronic ballast.
9.2	Toilets, Wash Rooms, etc.	70	Commercial channel mounted box type	Fluorescent tube (T5) with electronic ballast.
10.0	**400kV SWYD (as applicable)**			
10.1	Control Room	400	Decorative recessed mounted with mirror optics aluminum anodized reflector	2 x 28W FTL
10.2	Switchgear/Electrical Equipment room	200	Industrial type fluores-cent lamp with vitreous enamel reflectors up to mounting height of 3.5 M or Industrial medium bay integral luminaire for mounting heights between 3.5 to 8 M.	fluorescent tube (T5) with electronic ballast
10.3	Battery Room	200	Industrial Corrosion proof luminarie.	2 x 28W FTL.
10.4	Outdoor Operating Area	50	General purpose flood light	250 W/400 W HPSV lamp
10.5	General Outdoor Area	20	General purpose flood light	250 W/400 W HPSV lamp
11.0	**CHP Area**			
11.1	Transfer Point, Conveyor gallery, pent house, tunnel, Crusher house & Wagon Tippler	100	Dust proof / dust tight integral well glass	70 W HPSV/125 W HPMV lamp
11.2	Coal Stack yard/ Open area/ Marshalling yard	10	General purpose flood light & Integral type street Lighting luminaire with aluminium reflector	150 W/250 W/400 W HPSV lamp
12.0	Fuel Oil Tank	20	Industrial medium bay integral luminaire/ General purpose flood	250 W/400 W HPSV lamp

Sr. No.	Area/Structure	Average Illumination Level in Lux.	Type of Fixture / Luminaire	Type of Lamp
			light	
13.0	DC Emergency area Main Control room	50	Downlight luminaire, recessed type with cylindrical reflector	Incandescent lamp
14.0	DC Emergency other area	20	Industrial bulkhead luminaire	Incandescent lamp

* Medium bay fixtures shall be used where the room height is 8 M. Otherwise high bay fixtures are to be used.

Lux level for A.C. Emergency lighting in control room shall be 50 and for other areas 20 lux.

Lux level for main road lighting shall be 20 and for secondary road shall be 10 lux.

Lux level for D.C. Emergency lighting in main control room shall be 50 and for other areas 20 lux.

Area Wise Distribution of Lighting System

Sl.No.	Area	Normal AC	Emergency AC	Emergency DC	Portable DC
1.0	TG Building general	80%	20%	Yes	
2.0	Boiler platform	80%	20%	Yes	
3.0	DG / Compressor Room	80%	20%		Yes
4.0	ESP Control Room	80%	20%		Yes
5.0	Main Control Room	70%	30%	Yes	
6.0	Switchyard Control Room	100%			Yes
7.0	Battery Room	80%	20%		
8.0	Cable Spreader	80%	20%	Yes	
9.0	Pump house, Water Treatment Plant, Ash Handling Plant, Chemical house	100%			Yes
10.0	Cooling Tower, Transformer yard, Store, Switchyard, Area/Street lighting	100%			
11.0	Coal Handling Plant	100%		Yes	

ANNEXURE-D

RATINGS AND REQUIREMENTS
OF
LIGHTING / WELDINGTRANSFORMER

Type	:	Cast Resin Dry Type
KVA rating	:	to be finalized during detail engineering
Voltage rating	:	415 V/415 V
Cooling	:	AN
P.U. Impedance	:	0.045 ± 10%
Voltage control	:	Off load tap switch/link with change of ± 5% in step of 2.5% tapping full capacity.
Vector Group	:	Dyn11
Class of Insulation	:	F (155°C)
Maximum Temperature rise over 50°C. ambient in winding by resistance	:	90°C
Neutral	:	Solidly grounded.

The secondary neutral of the transformer shall be brought out for getting a grounded 4wire supply. Each transformer shall be routine tested and one transformer shall be type tested in accordance with relevant standard.

The transformer shall be liable for rejection if the tolerance on the quoted values of losses, impedance, temperature rise, etc. exceeds the specified values of relevant standard.

The transformer shall be mounted inside sheet steel enclosure, which shall be an integral part of Lighting Distribution Board.

ANNEXURE-E

FITTINGS AND ACCESSORIES OF LIGHTING / WELDING TRANSFORMER

Each transformer shall be equipped with fittings and accessories as listed below :

1. 150 mm dia. winding temperature indicator with maximum reading pointer and electrically separate sets of contacts for trip and alarm

2. Handling and lifting lugs both for enclosure and core-coil assembly.

3. Jacking pad for core-coil assembly.

4. Inspection cover for cable and box.

5. Door handle operated safety limit switch with 1NO + 1NC contact.

6. Ground bus.

7. IP-55 junction box.

8. Rating and terminal marking plates.

Note

All indication, alarm, trip contacts provided shall be rated for 2.0A at 220 V D.C. and 5A at 240 V A.C.

REFERENCES:

- IS–732: Code of practice for Elecrtical Wiring Installation.
- IS13408: Code of practice for the Selection, Installation and Maintenance of Electrical Apparatus for use in Ponentially Explosive Atmospheres (other than Mining Applications or Explosives Processing and Manufacture).
- National Building Code (NBC).
- National Electrical Code (NEC).
- Indian Electricity Rules.

NOTES & DETAILS:

1. The electrical installation work shall meet the requirements of Indian Electricity Rules, relevatn IS codes of practice and safety codes, as amended upto date. In addition, other rules or regulations as applicable to the work shall be followed.

2. These lighting notes and details shall be read and construed in conjunction with the Illumination Layout and drawings.

3. Except specifically approved by site office, installation of exposed conduits, mounting of lighting fixtures etc. shall be taken up only after all other services such as Piping, Air Ducting, Cable Tray/Busduct Hanger, Structural Bracings etc. in a particular area have been installed.

4. Unless otherwise shown, the mounting heights of lighting fixtures and accessories shall be generally as follows :

a)	i)	Low–Bay Lighting Fixtures in general indoor Areas of Industrial plants.	:	3500 mm from bottom to finished floor.
	ii)	Medium Bay Type Fixtures.	:	3500 to less than 8000 mm from bottom to finished floor.
	iii)	High Bay Type Fixtures	:	8000 mm and above from Bottom to finished floor.
	iv)	General indoor lightign for residential, commerical area	:	2700 mm from Bottom to finished floor.
b)		Lights over door Openings	:	300 mm bottom of fixture above top of opening.
c)		In Boiler Platform/ Platform around reactor column, reformer, cracker etc.	:	Pendant below Boiler platforms or with brackets from handrail 2000mm above platform.

A4_DD (9–96) [210x297]

d) Receptacles –

i)	In control room/office	:	450 mm from finished floor to centre
ii)	Elsewhere	:	900 mm from finished floor to centre
e)	Local Switches	:	1500 mm from finished floor to centre
f)	Lighting Panels	:	1800 mm from finished floor to top
g)	Ceiling Fans	:	200 mm above lighting fixtures

5. Unless otherwise noted, all lighting fixtures shall be fed from respective lighting panels. Normal AC lighting panels will be fed from Main lighting distribution boards (MLDB). Emergency AC lighting panels will be fed from Emergency Main lighting distribution boards (EMLDB). DC Emrgency lighting distribution boards (DCELDB) will be fed from MLDB and Main DC distribution boards.

6. All outdoor lighting poles/towers shall be provided with fuse/MCBs at their base while receiving incoming cable.

7. Separate neutral wire shall be provided for each circuit. Wiring throughout the installation shall be such that there is no break in the neutral wire in the from of switch or fuse.

8. All exposed conduit runs in battery room, chemical feed station area, water treatment building etc. shall be suitably painted with electrolytic/chemical proof paints.

9. The entire metallic conduit system whether embedded or exposed, shall be electrically continuous and thoroughly grounded.

10. Lighting fixtures shall not be suspended directly from junction box in the main conduit run.

11. Separate conduit shall be used for wiring lighting circuits of different lighting distribution system such as normal AC lighting/emergency AC lighting/emergency DC lighting/low voltage lighting.

12. A.C. and D.C. circuits shall not be run in the same conduit and junction boxes. Circuits fed from different transformers and different batteries (D.C. Source) shall not be run through same conduit and junction boxes.

13. Receptacle circuits shall be kept separate and distinct from lighting and fan circuits.

14. Wires/cable shall be spliced only at junction boxes with ring–tongue lugs or approved equal.

A4_DD (9–96) [210x297]

15. For cable/wire numbering, PVC sleeve with cable/wire Tag number of different colour code shall be used.

16. For roads/outdoor areas, main runs from street/area lighting panels shall be by means of AYWY/AYFY/A2XFY cables, directly buried in ground with proper protection as per details shown or through duct bank.

17. When buried cables cross road/railway track, additional protection to be provided in from of Hume/G.I. Pipe/HDPE pipes. GI pipes/Hume pipes shall not be used for single core cable run.

18. All wiring in hazardous areas shall be carried out either with armoured cables or cables drawn in screwed solid or sameless conduit.

19. For classified hazardous area (othe than mines) havining flammable gases and vapors only, all the items and accessories of illumination system shall have enclosure as provided for the hazardous area classification (Zone 0, Zone 1 and Zone 2) as per code of standard IS-5571 and 5572.

    Lamps containing free matallic sodium (e.g. low pressure sodium vapour lamps) are not permitted for use in hazardous areas.

20. In underground mines, the lighting system shall have a mid or neutral point connected with earth and the voltage shall not exceed 125 volts between phases.

    On the surface of a mine or in an open cast mine, the voltage may be rised to 250 volts, if the neutral fo mid point of the system is connected with earth and voltage between the phases does not exceed 250 volts.

    Where portable hand-lamps are used in under ground working of mine, the voltage shall not be exceed 30 volts.

21. Number of receptacles in an area shall be decided based on utility of this area. However, unless otherwise noted, number of receptacles shall generally be selected based on following guidelines:

    a) For Residental Building, 6A and 16/6A single-phase receptacles shall be considered as per NBC.

    b) For general area (e.g. Electrical room, Pump room, Contro room) of Plant Building. 16/6A receptacle shall be considered.

    c) One (1) number 63A three-phase receptacle shall be provided at each generator busduct area, at each generator-transformer area, station-transformer area, transformer area at switchyard, bioler area, major pump rooms.

A4_DD (9-96) [210x297]

d) 63A three phase receptacle shall be provided at each turbine bay, at eachboiler area, etc. for use of welding machine.

e) Inindustrial plants, 63A three–phase receptacles shall be dicided based on the application requirement.

f) 24v singel–phase receptacle shall be used in boiler platform area and vessels platforms (e.g. reactor, reformers etc.) hazardous classified area. The number shall be decided based on application and area.

22. Unless otherwise noted, the minimum size of cables, wires, conduits, junction boxes shall be as below :

A) CABLES

i)	From main lighting distritbution Boards to 400 V normal AC lighting panels	:	1x3–1/2C, 95 Sq.mm AL PVC/XLPE
ii)	From Emergency main lighting distritbution Boards (EMLDB) to 400v Emergency AC lighting panels.	:	1x3–1/2C, 95 Sq.mm AL PVC/XLPE
iii)	From Main Lighting Distribution Boards (MLDB) to 400V AC/220V DC Emergency Lighting Distribution Boards (DCELDB)	:	1x3–1/2C, 95 Sq.mm AL PVC/XLPE
iv)	From Main Lighting Distribution Boards (MLDB) to 400V AC/220V DC Emergency Lighting Distribution Boards (DCELDB)	:	1x3–1/2C, 95 Sq.mm AL PVC/XLPE
v)	From PMCC/MCC/DB to 100A 3 phase receptacles	:	1x3–1/2C, 95 Sq.mm AL PVC/XLPE
vi)	From PMCC/MCC/DB to 63A 3 phase receptacles	:	1x4C, 35 Sq.mm AL PVC/XLPE
vii)	From SLP (Street Lighting Panel) to tower junction box	:	1x4C, 16 Sq.mm AL PVC/XLPE
viii)	From SLP to light pole junction box (for single phase)	:	1x2C, 16 Sq.mm AL PVC/XLPE
ix)	From SLP to light pole junction box (for three phase)	:	1x4C, 16 Sq.mm AL PVC/XLPE

A4_DD (9–96) [210x297]

B. WIRES

Wires shall generally be PVC insulated650V grade. Each wire shall be of following sizes:

i)	From lighting panels (LPs) to Junction Boxes	:	10sqmm AL (stranded) or 6 sqmm Cu (stranded)
ii)	From junction boxes (JBs) to lighting fixtures	:	2.5sqmm Cu
iii)	From junction boxes to flood light fixtures	:	2.5sqmm Cu
iv)	From lighting panels to 24V AC supply modules (complete with 230/24V built–in transformer & 24V receptacle)	:	10sqmm AL (stranded) or 6 sqmm Cu (stranded)
v)	Point wiring of light/celling fan/exhaust fan/call bell	:	1.5sqmm Cu (stranded)
vi)	230V, 6A receptacle	:	1.5sqmm Cu (stranded)
vii)	From LP to 230V, 16/6A 1st receptacles	:	4sqmm Cu (stranded)
viii)	From 230V, 16/6A 1st receptacle to 230V 16/6A second receptacle	:	2.5sqmm Cu (stranded)
ix)	From LP to 230V, 20/6A receptacles	:	4sqmm Cu (stranded)
x)	230V window/split AC starter unit upto 2 Ton capacity	:	4sqmm Cu (stranded)
xi)	Circuit wiring from LP to switchboard	:	2.5sqmm Cu (stranded)
xii)	From street light panel to lighting pole JB (if conduit used)	:	16sqmm AL (stranded) or 6 sqmm Cu (stranded)
xiii)	From street light pole junction box to street light fixture	:	2.5sqmm Cu (stranded)

A4_DD (9–96) [210x297]

C. CONDUITS

a) Unless otherwise noted, in residential and commerical building, PVC conduit shall generally be used for concealed conduiting purpose both in masonry wall as well as in concrete portion. Two numbers 18 SWG GI fish wires shall be drawn inside each conduit while embedding in concrete portion. At both ends of each conduit a minimum 400mm length of fish wiers shall be ketp by cooling, for pulling of wires. All exposed conduits above false celling shall be Galvanised Iron (GI) or Enameled Iron (EI).

b) In plant area GI conduit shall be used at surface. Unless otherwise noted, in Non–Plant building rigid PVC conduit shall be used at surface.

c) Conduits shall generally be Galvanised Iron (GI)/ Enameled Iron (EI)/PVC of following minimun sizes:

	Wire Size	Conduit. Size					
		20MM	25MM	32MM	40MM	50MM	
i)	10 Sq.mm AL	–	2	5	7	8	Maximum no. of wires admissable for conduit
ii)	6 Sq.mm Cu	2	3	7	–	–	
iii)	4 Sq.mm Cu	3	5	10	–	–	
iv)	2.5 Sq.mm CU	4	6	10	–	–	
v)	2.5 Sq.mm CU	4	6	10	–	–	

D. JUNCTION BOXES

	Conduit Size (MM)	Junction Box Size (MM)			
		4–WAY	3–WAY	STRAIGHT THROUGH	90°
i)	20 / 25	150x150x100	150x100x100	88 ø	88 ø
ii)	32 / 40	254x200x127	254x200x127	150x150x100	–
iii)	50	254x200x127	254x200x127	254x200x127	–

A4_DD (9–96) [210x297]

23. All lighting panels/distribution boards, junction boxes, receptacles fixtures, conduits, etc. shal be grounded in compliance with the provision of I.E. rules and as detailed below :

i)	LIghting Panels	:	35 x 6 mm G.S. Flat
ii)	Distribution Boards	:	50 x 6 mm G.S. Flat
iii)	Power receptacles Junction Boxes etc.	:	12 SWG G.I. Wire
iv)	Lighting fixtures, switches conduits, etc.	:	16 SWG G.I. Wire
v)	Street Light Poles and Towers for floodlighting	:	25 x 3 mm G.S. Flat

24. A continious ground conductor of 16 SWG GI.wire shall run along each exposed metallic conduit run and bonded to it every 600mm.

25. For a run of conduit partly or wholly embedded, PVC insulated stranded copper conductor wire, as ground conductor shall run through the conduit.

26. Typical details of lighting fixtures, other lightign system components and their mounting arrangement as shown herein are for general guidance only. The type no. of some make has been referred in the various drawings only to indicate desired appearance and construction features of the fixture. The contactor has to design the same fulfilling the requirement of the specification.

A4_DD (9-96) [210x297]

VOLUME: V-A

SECTION-VII

TECHNICAL SPECIFICATION
FOR
415V PMCC/MCC, 415V ACDB AND 220V DCDB

CONTENTS

CLAUSE NO.	DESCRIPTION
1.00.00	SCOPE OF SUPPLY
2.00.00	CODES AND STANDARDS
3.00.00	DESIGN CRITERIA
4.00.00	SPECIFIC REQUIREMENTS
5.00.00	TESTS
6.00.00	DRAWINGS, DATA AND MANUALS

ATTACHMENTS

ANNEXURE-A	RATINGS AND REQUIREMENTS
ANNEXURE-B	PROTECTIONS
ANNEXURE-C	FITTINGS & ACCESSORIES
ANNEXURE-D	BUS TRANSFER SCHEME FOR PMCC

DRAWINGS

TYPICAL SINGLE LINE DIAGRAM

TYPICAL CONTROL SCHEMATIC

VOLUME :V-A

SECTION-VII

TECHNICAL SPECIFICATION FOR 415V PMCC/MCC, 415V ACDB AND 220V DCDB

1.00.00 SCOPE OF SUPPLY

1.01.01 Requisite nos. of following equipment shall be furnished with all accessories :-

a. Power cum Motor Control Centre (PMCC)
b. Motor Control Centres (MCC)
b. A.C. Distribution Board (DB)
c. D.C. Distribution Board (DB)
d. D.C. Starters
e. Lockout Switches
f. A.C./D.C. fuse boards

1.01.02 The base channel frame with hardware and lifting angles.

1.01.03 One set of special tools and tackles.

1.01.04 Set of accessories as listed below :

a) Breaker lifting and handling trolley.

b) Test cabinet with coupling cables for testing the breaker in drawout position.

c) Racking in/out handle for breakers.

1.01.05 12kV rubber mats shall be provided both at front and rear of LT Switchgear.

1.01.06 Mandatory Spare parts.

1.01.07 All relevant drawings, data and instruction manuals.

2.00.00 CODES AND STANDARDS

2.01.01 All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) and IEC except where modified and/or supplemented by this specification.

2.01.02 Equipment and material conforming to any other international standard which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

2.01.03 The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

3.00.00 **DESIGN CRITERIA**

3.01.00 The PMCCs/MCCs/DBs will be used to provide power, control and protection for 415/240V A.C. and 220V D.C. auxiliary services (Motors & Feeders) of generating units.

3.02.00 Duty involves direct-on-line starting of large squirrel cage motors below 175kW. The starting current varies from 6 to 8 times rated current at very low power factor.

3.03.00 The equipment will be located in a hot, humid and tropical atmosphere, highly polluted at places with coal dust and/or fly ash.

3.04.00 For continuous operation at specified ratings, the temperature rise of various equipment/components shall be limited to the permissible values stipulated in relevant standards and/or this specification.

3.05.00 Equipment ratings and quantities are detailed in the enclosed drawings and annexure. Equipment shall be furnished in strict compliance with the same.

3.06.00 All equipment and components thereof shall be capable of withstanding the mechanical forces and thermal stresses of the short-circuit currents without any damage or deterioration of the materials.

3.07.00 The PMCCs/ MCCs / DBs shall have two incomers and one bus-coupler. In addition to electrical interlocks, mechanical castle key interlock shall be provided between the two incomers and the bus-coupler so that any two of the three may be closed at a time.

3.08.00 Busbars of PMCCs shall be sized to carry continuously the associated transformer secondary current plus a 20% margin.

Busbars of MCC/DBs shall be sized to carry continuously the total running load of MCC/DB plus a 20% margin.

3.09.00 In cubicle of incomers & bus section breakers/MCCBs shall be identical to the associated busbar rating.

3.10.00 For continuous operation at specified ratings, the temperature rise of various equipment/components shall be limited to the permissible values specified in relevant standards and/or this specification.

3.11.00 Circuit breakers shall not produce any harmful over voltage during switching off of induction motors. If required, surge protective devices shall be included in the scope of supply to limit over voltages.

3.12.00 Incomers, Bus-couplers & outgoing feeders rated upto & including 630A shall be MCCB controlled. Above 630A all incomers, Bus-couplers & outgoing Feeders shall be ACB controlled. For critical loads ACB controlled feeders shall be provided which will be decided during detail engineering.

3.13.00 All motor rated 110kW & above, below 175kW shall be ACB controlled. Motor rated upto 110kW shall be contactor operated.

3.14.00 MCC & PMCC shall have sufficient number of spare modules (at least 20% of various sizes used with a minimum of 1 no. for each rating and type).

3.15.00 Outgoing feeders of PMCC shall be limited to minimum number of different sizes so that max. standardization is achieved from MCCB & contactor size point of view.

3.16.00 Incomers & bus section breakers of PMCCs/MCCs shall have provisions for remote operation from control room.

3.17.00 All breaker operated motor feeder shall be supplied from PMCC.

3.18.00 One no. Normal/Emergency switchgear to cater power supply to important emergency load / motors for safe shut-down of unit including 220V battery chargers shall be provided for each unit. The main incoming supply shall be from 415V unit service switchgear. When main incoming supply fails, reserve incoming supply shall be switched ON automatically from 415V station service switchgear. In case of total failure of AC supply of the power station, the supply from DG shall be switched ON automatically.

3.19.00 Each switchgear shall be provided with two bus sections, two incomer and a bus coupler rated for 100% of the loads connected to the switchgear.

3.20.00 For each auxiliary or load, one feeder shall be provided except for the following cases:

One feeder for a maximum 2 nos. isolator motor operating mechanism.

3.21.00 The switchgears shall be provided with suitable number and type of outgoing feeders for the respective auxiliary loads of the system/area, power supply feeders to various panels, lighting transformer, space heating panels, control cabinets and all other loads encountered in the plant. In addition, following feeders shall be provided in each bus section of each switchgear.

a) Bus VT module: One (1) no.

b) Switchgear test supply module: One (1) no.

c) 240V, 1 phase essential supply module with five nos. 1 phase outlets: One (1) no.
Necessary 415V/240V dry type transformer shall be provided.

d) Alarm module for common alarm for outgoing feeder fault: One (1) no.

e) DC supply alarm module for incomer, bus coupler fault: One (1) no.

3.22.00 Each feeder shall be provided with two nos. interposing relays for start & stop. These interposing relays shall be located in separate IPR panel described under C&I specification.

4.00.00 **SPECIFIC REQUIREMENTS**

4.01.00 **Construction**

4.01.01 PMCC / MCC / DB shall be indoor, metal-clad, air insulated and floor mounting type. All MCCs shall be fully draw out type and DBs shall be fixed type. ACB modules of PMCCs/MCCs shall be fully drawout type. MCCB / Switch Fuse modules shall also be fully drawout type. The design and construction shall be such as to allow extension at either end.

4.01.02 All PMCC/MCC shall be of double front construction.

4.01.03 PMCC /MCC/DB enclosure shall be dust and splash proof, conforming to a degree of protection IP-54. All switchboard frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness 2.0mm. Frames shall be enclosed in cold rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot/cold rolled sheet steel and 4.0 mm for non-magnetic material.

4.01.04 PMCC / MCC / DB assembly shall comprise a continuous line up of dead front, free-standing vertical sections, housing the control modules in multi tier formation.

4.01.05 The design shall be fully compartmentalized with metal/insulating partitions between compartments. The working height shall be limited within 750 mm to 1800 mm from floor level.

4.01.06 Each control module shall be housed in a separate compartment, complete with an individual front access door having sufficient opening with concealed type hinges. Each vertical section shall have a removal back cover. All doors and covers shall be gasketed.

4.01.07 All push buttons, lamps, indicating instruments shall be flush / semi-flush mounted on respective module compartment.

4.01.08 A full height vertical cable chamber with cable supports shall be provided in each section to facilitate unit wiring. The chamber shall be liberally sized to accommodate all cables and shall have removable cover at the front for access.

4.01.09 A horizontal wireway, extending the entire length, shall be provided at the top of each PMCC / MCC / DB for inter panel wiring.

4.01.10 The width of the cable alley shall not be less than 250 mm.

4.02.00 **Bus and Bus Taps**

4.02.01 All PMCCs/MCCs/DBs shall be provided with three phase & neutral bus bars . All DCDBs shall be provided with two busbars. All busbar compartments shall be completely enclosed.

4.02.02 The main buses and connections shall be of high conductivity Aluminium / Aluminium alloy, sized for specified current ratings with maximum temperature limited to 85°c (i.e., 35°C rise over 50°C ambient).

4.02.03 Vertical busbars shall be designed for minimum current rating of 200A. Separate vertical busbars shall be provided for each vertical panel.

4.02.04 All bus connections shall be silver plated. Adequate contact pressure shall be ensured by means of two-bolt connection with plain and spring washers and locknuts.

Bimetallic connector shall be furnished for connection between dissimilar metals.

4.02.05 Busbars and connections shall be fully insulated for working voltage with adequate phase/ground clearances. Insulating sleeves for busbars and shrouds for joints and tap-off points shall be provided.

Bus insulators shall be flame retardant, non-hygroscopic track-resistant type with high creepage surface.

4.02.06 Busbars shall be supported and braced to withstand the stresses due to maximum short circuit current and also to take care of any thermal expansion.

4.02.07 Busbars shall be colour coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear when viewed from the front of the assembly.

4.03.00 **Control Modules**

4.03.01 Draw-out type control module shall have self-aligning power/control disconnects. All disconnects shall be silver plated to ensure good contacts.

4.03.02 The design shall be such as to permit easy withdrawal/reinsertion of the unit with guide rails to ensure correct alignment.

4.03.03 Control Module shall house the control components for a circuit such as switch fuse / MCCB, contactors, relays, push buttons, lamps etc. as per requirement of the control circuit.

4.03.04 The equipment layout shall provide sufficient working space in between the components and subject to Owner's approval.

4.03.05 Various module/compartment sizes shall be multiple of one basic unit to facilitate modifications at site. Suitable provision for this purpose should also be incorporated in the vertical bus bars.

4.03.06 Draw-out type control modules of same size and type shall be electrically and physically interchangeable.

4.04.00 **Air Circuit Breaker**

4.04.01 Circuit breaker shall be provided on the incomer having minimum interrupting capacity equal to the 50kA(r.m.s) fault level.

4.04.02 Circuit breaker shall be three pole, single throw, air-break type with independent manual spring closing, trip-free mechanism and shunt trip. However Incomer breaker shall be four pole type.

4.04.03 Circuit breaker shall be draw-out type, having service, test & isolated position with positive indication for each position.

4.04.04 Circuit breakers of identical rating shall be physically and electrically interchangeable.

4.04.05 Each breaker shall be provided with microprocessor based protection unit having three overload protection with adjustable current and time, three short circuit protection with adjustable current and time and three instantaneous short circuit protection. The operating characteristic shall be suitable for co-ordination with down-stream fuses.

4.04.06 Circuit breakers shall be provided with motor wound spring charging mechanism. Spring charging shall take place automatically after each breaker closing operation. One open-close-open operation of the circuit breaker shall be possible after failure of power supply to the motor. In addition, facility for manual charging of spring shall be provided.

4.04.07 Mechanical safety interlock shall be provided to prevent the circuit breaker from being racked in or out of the service position when the breaker is closed. It shall not be possible to open the circuit breaker door cubicle unless the breaker is in 'OFF' position.

4.04.08 Automatic safety shutters shall be provided to cover up the stationary disconnects when the breaker is withdrawn.

4.04.09 Each breaker shall be provided with an emergency manual trip, mechanical ON-OFF indicator, an operation counter and spring mechanism charge/discharge indicator, and electrical anti-pumping feature.

4.04.10 In addition to the auxiliary contacts required for normal breaker operation and indication, each breaker shall be provided with the following for interlocking purpose :-

a. Position/Cell switch with 4 NO + 4 NC contacts.

b. Auxiliary switch, with minimum 6NO + 6NC contacts,

4.04.11 Spring charge limit switch shall be provided for breakers with motor wound spring charging mechanism. These limit switches shall be provided with minimum 2NO + 2NC contact.

4.04.12 Limit/auxiliary switches shall be convertible type, that is, suitable for changing N.O. contact to N.C. and vice-versa.

4.04.13 Each breakers operated feeder shall be provided with protective devices as specified in Annexure–B.

4.05.00 **Switches**

4.05.01 Switches shall be triple pole, air break, AC23 motor duty for motor feeders and AC22 heavy duty for other feeders.

Motors duty switches shall be capable of safely making and breaking the locked rotor current of the associated motor circuit.

4.05.02 The switch shall have a quick-make, quick-break mechanism operated by a suitable external handle, complete with position indicator. This handle shall have provision for padlocking in ON and OFF position.

4.05.03 The compartment door shall be interlocked mechanically with the switch such that the door cannot be opened unless the switch is in OFF position. Means shall be provided for releasing this interlock at any time.

4.05.04 Switches shall be capable of withstanding the let-through fault current of back-up fuses or circuit breakers.

4.05.05 Wherever two incoming switches and one bus-section switch are provided for an assembly, these shall be mechanically/key interlocked to ensure that only two out of the three can be closed at time.

Wherever two incoming switches are provided for an assembly, these shall be mechanically/key interlocked to ensure that one of the two can be closed at time.

4.05.06 All incoming and outgoing feeders shall be provided with bolted disconnect link for isolation of neutral if necessary.

4.06.00 **Fuses**

4.06.01 Fuses shall be HRC, preferably link type, with a minimum interrupting capacity equal to the short circuit current of the LT system. Fuses shall be mounted on insulated fuse carriers, which are mounted on fuse bases. Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug-in type of base. In such cases, one set of insulated fuse pulling handles shall be supplied with each board.

4.06.02 Fuses shall be furnished complete with fuse bases and fittings of such design as to permit easy and safe replacement of fuse element.

Visible indication shall be provided on blowing of the fuse.

4.06.03 Motor fuse characteristics and ratings shall be chosen to ride over starting period without blowing. The fuse on incoming feeder wherever provided, shall be chosen to provide discrimination with motor/feeder fuses.

4.07.00 **Moulded Case Circuit Breaker (MCCB)**

4.07.01 The MCCBs shall be of drawout type with trip-free operating mechanism of quick make & quick break type. Each MCCB shall be equipped with thermal release for thermal overload and magnetic release for short circuit protection on each pole.

4.07.02 MCCBs / MPCBs shall be suitable for manual closing and opening and also automatic trip on overload and short circuit. MCCB shall have intermediate position to indicate trip condition.

4.07.03 The MCCBs shall be provided with mechanical ON-OFF indicator at the front panel. The MCCB handles, after the breaker tripped due to faults, shall occupy a mean position indicating trip condition.

4.07.04 The compartment door shall be interlocked mechanically with the MCCB such that the door cannot be opened unless the MCCB is in OFF position. Means shall be provided for releasing this interlock at any time.

4.07.05 All feeders of PMCC / MCC rated up to & including 630 Amp shall be provided with MCCB. Air circuit breaker shall be provided for feeders rated above 630 Amp. For critical loads ACB controlled feeders shall be provided which will be decided during detailed engineering.

4.07.06 Motors rating above 110 KW will be operated by Air circuit breaker and protected by consolidated numerical motor protection relay.

4.08.00 **A.C. Starter**

4.08.01 Contactors

a. The contactors shall be three pole, air break type designed for duty class III - Category AC3 (for unidirectional motor) with non-bouncing silver/ silver alloy contacts. Contacts for reversible motors will be of AC4 duty.

b. Each contactor shall be provided with minimum two (2) normally open and two (2) normally closed auxiliary contacts rated 10 A at 240V A.C.

c. Reversing contacts shall be electrically and mechanically interlocked.

d. Contactors with delayed dropout feature shall be provided for some essential auxiliaries. These contactors shall not dropout on power failure if the voltage is restored within 3 seconds.

4.08.02 **Protection**

a. Thermal overload relays shall be three element, positive acting, ambient temperature compensated with adjustable settings.

b. Single phase preventor relay shall be provided, preferably as an inbuilt feature of thermal overload relay.

c. Relays shall be manual reset type with two changeover potential-free contacts. Resetting of relays shall be possible with compartment door closed. Colour of the resetting button shall be BLACK.

d. Relays may be direct acting or C.T. operated, depending on current rating. C.T.s shall be included in the scope of supply.

e. Motor starters shall have type '2' co-ordination according to IEC 947-4.

f. Earth fault relays with adjustable settings and time delays fed from core balance CT shall be provided.

g. Numerical / Digital Motor protection relay with short circuit, over load, earth fault, locked rotor and unbalance (NPS) load protection functions shall be provided for motor rated above 90 kW.

4.09.00 **Control Transformer**

4.09.01 LT Switchboard control supply

The Bidder shall provide one (1) no. adequately rated 415V/110V Control Transformer in each bus section with necessary taps and auto changeover facility for providing control power supply to various modules of the board, except motor feeders. Each motor feeder shall be provided with 415/110V control transformer of adequate capacity (min. 75VA) for control supply to such module. The sizing of control transformer shall be carried out by the Bidder considering the actual load of power contactors, auxiliary contactors, indicating lamps and other equipment in the module circuit. An additional load of 15watts shall be considered for each module for remote auxiliary relays and lamps to be connected in the control circuit of modules. Bidder shall also ensure that control transformer are adequately designed for meeting the momentary loading requirements and the voltage drop during this condition shall not be more than 5%. Each transformer shall be sized for catering to control supply of both bus sections.

4.09.02 LT Switchboard space heater supply

The Bidder shall provide one (1) no. adequately rated 415V/240V Control Transformer in each bus section with necessary taps and auto changeover facility for providing power supply to panel space heater, Motor space heater of motor rated 30 KW & above, Panel Illumination & Socket. The supply of these two (2) nos. control transformer are tapped from incoming supply of 415V PMCC/MCC before the incoming breaker. Incoming circuit to the space heater auxiliary bus shall be through isolating switch HRC fuse and neutral link of suitable rating. The supply of different modules shall be tapped individually from the auxiliary bus bars. Control supply healthy indication shall be provided. Each transformer shall be sized for catering to space heater supply of both bus sections.

4.10.00 **D.C. Starters**

4.10.01 D.C. Starter for emergency oil pump shall be fixed resistance type, designed to provide fast acceleration during starting.

4.10.02 DC starters shall be complete with switch-fuse units, contactors, resistors, relays, meters, push-buttons, lamps, etc.

4.10.03 Starters shall be furnished in totally enclosed floor-mounting, sheet steel cubicles complete with a hinged front access door. Minimum thickness of sheet steel shall be 2mm.

4.10.04 The cubicle enclosure shall provide dust and humidity protection, the degree of protection being not less than IP-54.

The resistor enclosure shall be provided with ventilating louvers and wire mesh guard and shall have a degree of protection IP-23.

4.10.05 Cubicle space heater shall be provided to maintain internal temperature above dew point. Heater shall be furnished with switch-fuse unit and thermostat control.

4.11.00 **Relays**

4.11.01 All incoming and bus-coupler circuits and circuit breaker operated outgoing feeders shall be provided with numerical relays. Breaker operated motor feeders shall be provided with numerical motor protection relay.

4.11.02 The numerical relays shall have provisions for interfacing with Plant DDCMIS / PLC.

4.11.03 Relays shall be of drawout design with built-in testing facilities. Small auxiliary relays may be in non-drawout execution.

4.11.04 All protective relays, auxiliary relays, and timers shall be provided with hand reset operation indicator (flag).

4.11.05 Relays shall be rated for operation on 110V secondary voltage and 5 A or 1 A. Number and rating of relay contacts shall suit the job requirements.

4.12.00 **Control and Indication**

4.12.01 Circuit breakers shall be wired up for local and remote operation. Each breaker cubicle shall be equipped with the following :

i) One (1) TEST-NORMAL-TRIAL selector switch with pistol grip handle and key interlock for breakers with motor wound spring charging mechanism.

ii) On-Off control switches shall have three positions (T-N-C) and shall be spring return to 'Neutral' from close and trip positions. They shall have two contacts closing in close position and two contacts closing in trip positions, and shall have Pistol Grip handles. Lost motion feature shall be provided wherever required.

iii) Following indicating lamps on the front of the compartment:

Breaker open	-	GREEN
Breaker closed	-	RED
Breaker tripped	-	AMBER
Spring charged	-	WHITE
Trip Ckt. Healthy	-	BLUE

Motor Space heater ‘ON’ for motor circuit - YELLOW

4.12.02 Push button shall be heavy duty, oil tight, push to actuate type with integral escutcheon plate marked with its function.

4.12.03 Each push button shall have minimum two (2) nos. normally open and two (2) nos. normally closed contacts rated 10 A at 240 V.

4.12.04 One (1) NORMAL-TRIAL selector switch shall be provided for all motor feeders.

4.12.05 Selectors switches shall be stay-put, rotary type with escutcheon plates marked to indicate the function and positions, and shall be lockable in each position. Selector switch contacts shall be rated for 10A at 240 V A.C.

4.12.06 Selector switches shall be provided with minimum three (3) contact blocks of 1 NO + 1 NC each.

The exact requirements of contacts shall be decided by the Tenderers taking into account the scheme requirement and spares.

4.12.07 Lamps shall be clustered LED type with series resistor and coloured lens. Lens and lamps shall be replaceable from the front. Lamps shall be located just above the associated push button/control switch

4.12.08 The general scheme of connections for control, interlock and protection is shown in the enclosed drawings. Detailed requirements of individual circuits will be intimated later to the successful bidder, who shall develop and furnish the schemes accordingly.

4.13.00 **Meters**

4.13.01 All indicating instruments (96 x 96 mm) shall be switchboard type, with 250` scale, anti-glare glass and accuracy class of ± 2% full scale. Each meter shall have zero adjuster on the front.

4.13.02 Motor ammeter shall be suitable to indicate starting current (6 to 8 times full load current) for DOL starting of motor.

Motor ammeter shall be provided for motor rated 30 kW and above and for critical drives, to be finalized during detail engineering.

4.13.03 All incomers, tie feeders, circuit breaker operated motor feeders shall be provided with 3-phase multifunction meter with pulse output and communication port for interfacing with Plant DDCMIS / PLC.

4.13.04 Meter selector switches shall be maintained contact, stay-put type, with knob handle. Ammeter and voltmeter selector switches shall be four position type. Ammeter selector switches shall have made before break contacts, to prevent open circuiting of CT secondary.

4.14.00 **Current Transformer**

4.14.01 Current Transformer, shall be cast resin type rated 10 VA. All secondary connections shall be bought out to terminal blocks where wye or delta connection will be made.

4.14.02 Accuracy class of the current transformers shall be:

a) Class PS for REF

b) Class 5P20 for other relaying.

c) Class 1.0 ISF < 5 for metering.

d) Class 0.5 ISF < 5 for metering (Incomer & Bus coupler of PMCC)

Other CT particulars like ratio, burden, knee point, excitation current & secondary resistance shall be decided by the bidder.

4.14.03 CT secondary shall be rated for 1A for metering & either 5A or 1A for protection.

4.15.00 **Voltage Transformer**

4.15.01 Voltage transformers shall be cast-resin, drawout type and shall have an accuracy class of 1.0. Voltage transformer mounted on breaker carriage is not acceptable. For Incomer and bus coupler of PMCC accuracy class of voltage transformer shall be 0.5.

4.15.02 High voltage windings of voltage transformer shall be protected by current limiting fuses. The voltage transformer and fuses shall be completely disconnected and visibly grounded in fully draw out position.

4.15.03 Secondary winding MCBs, sized to prevent overload shall be installed in all ungrounded secondary leads. MCBs shall be suitably located to permit easy replacement while the switchgear/PMCC is energized.

4.15.04 Both primary side & secondary side fuse failure / voltage loss monitoring system of VT shall be provided.

4.16.00 **Transducers**

4.16.01 Transducer for conversion of AC electrical quantities such as voltage, current, KW etc. shall be supplied as required for remote connection to Plant DDCMIS / PLC. All transducers shall be dual output type.

4.16.02 The transducers for indicating type instruments shall be of very low burden type having 4-20 mA DC linear, galvanically isolated output, compatible with secondary instruments and Plant DDCMIS system.

4.17.00 **Secondary Wiring**

4.17.01 The PMCC/MCC/DB shall be fully wired at the factory to ensure proper functioning of control, protection and interlocking schemes.

4.17.02 Fuse and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, push buttons and other devices shall be wired upto terminal blocks.

4.17.03 Wiring shall be done with flexible, 1100V grade, fire resistance PVC insulated switchboard wires with stranded Copper conductors of 2.5 mm^2 for control & current circuits and 1.5 mm^2 for voltage circuits.

4.17.04 Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per Contractor's wiring diagrams.

4.17.05 Wire terminations shall be made with crimping type connector with insulating sleeves. Wires shall not be spliced between terminals. Separate colour code shall be used for AC & DC circuit wiring for easy identification.

4.18.00 **Terminal Blocks**

4.18.01 Terminal blocks shall be 1100V grade box-clamp type with marking strips similar to ELMEX 10 mm^2 or equal. Terminals for C.T. secondary leads shall have provision for shorting.

4.18.02 Terminal blocks used for interface with DDCMIS / PLC via termination cabinet shall be suitably sized to facilitate proper termination of interconnecting cables.

4.18.03 Not more than two wires shall be connected to any terminal. Spare terminals equal in number to 20% active terminals shall be furnished.

4.18.04 Terminal blocks shall be located to allow easy access. Wiring shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.

4.19.00 **Cable Terminations**

4.19.01 PMCC shall be designed for cable entry from bottom. MCC/DB shall be designed for cable entry both from top and bottom. Actual configuration shall be intimated later sufficient space shall be provided for ease of termination and connection.

4.19.02 Power cables shall be 1100V, Copper/Aluminum conductor, XLPE insulated, armoured, FRLSH PVC overall sheathed.

Control cables shall be 1100V, PVC insulated, armoured, PVC overall sheathed with 2.5 mm^2 stranded Copper conductor.

4.19.03 All provisions and accessories shall be furnished for termination and connection of cables, including removable gland plates, cable supports, crimp type tinned Copper/Aluminium lugs, brass compression glands with tapered washer (Power Cables only) and Terminal blocks.

4.19.04 Sufficient space shall be provided between the lower most power cable termination and gland plate for easy cable connection.

4.20.00 **Bus Duct Connection**

4.20.01 Bus duct connections shall be furnished along with transition panel, if required. Unless mentioned otherwise bus duct connections shall generally be from the top.

4.20.02 All connecting bus work shall have the same continuous current rating as associated PMCC bus and shall be fully braced for the LT system short circuit current.

4.20.03 All provisions such as matching flange and other accessories shall be furnished for connection to bus duct.

4.21.00 **Ground Bus**

4.21.01 A Cu / Al ground bus rated to carry the maximum fault current, shall extend full length of the MCC/DB.

4.21.02 The ground bus shall be provided with two-bolt drilling with G.I. bolts & nuts at each end to receive 50 x 6 mm G.I. flats.

4.21.03 All stationary structures shall be directly connected to the ground bus for effective grounding.

4.21.04 The frame of draw out module shall be grounded at all times except when the power disconnects are separated by a safe distance.

4.21.05 All hinged doors shall be earthed through flexible copper braid wire.

4.22.00 **Nameplate**

4.22.01 Nameplate of approved design shall be provided for each control compartment and also at the top of each PMCC / MCC / DB.

4.22.02 The material of the name plate shall be anodized aluminium / lamicoid or approved equal, 3 mm thick, with white letter on black background. Name plates shall be minimum 20 x 75 mm for instrument / devices and 40 x 150 mm for panels.

4.22.03 Caution notice on suitable metal plate shall be affixed at the back of each vertical panel.

4.23.00 **Space Heater**

4.23.01 Panel and motor space heater shall be fed from separate AC auxiliary busbars running throughout the switchboard. The space heater bus shall be fed from control transformer described earlier. Suitable terminals shall also be provided to facilitate energisation of the control transformer from outside during long shutdown of the board.

4.23.02 Each vertical section of the PMCC / MCC / DB shall be furnished with thermostat controlled space heater and 5A, 5 pin plug socket.

4.23.03 In addition, motor feeders 30 KW and above shall be wired up for feeding motor space heater through starter auxiliary ‘OFF’ contacts.

4.23.04 Cubicle heater, Motor heater and plug socket circuit shall be provided with individual MCB/switch fuse units.

4.24.00 **A.C./D.C. Power Supplies**

4.24.01 Necessary 415V AC and 220V DC power supplies as required for control and service shall be arranged by the contractor. Single feeder shall be arranged for A.C. supply and duplicate feeder shall be arranged for D.C. supply.

4.24.02 Isolating switch fuse units shall be provided at each switchgear for the incoming supplies, 4-pole, single throw for A.C. and 2-pole, double throw for D.C. Molded case circuit breaker (MCCB) shall also be accepted as an alternative.

4.24.03 Bus-wires of adequate capacity shall be provided to distribute the incoming supplies to different cubicles. Isolating switch fuse units / MCCB shall be provided at each cubicle for A.C/D.C. supplies.

4.24.04 A.C. load shall be so distributed as to present a balanced loading on three-phase supply system.

4.25.00 **Tropical Protection**

All equipment, accessories and wiring shall have fungus protection, involving special treatment of insulation and metal against fungus, insects & corrosion.

Screens of corrosion resistant material shall be furnished on all ventilating louvers to prevent the entrance of insects.

4.26.00 **Painting**

4.26.01 All steel surfaces shall be sand blasted, grounded and pickled as required to produce a smooth, clean surface free of scale, grease & rust.

4.26.02 After cleaning, the surfaces shall be given a phosphate coating followed by two coats of high quality primer and stoved after each coat.

4.26.03 For paint shade of finish coat, refer clause no.1.16.00 of Section E1, Volume V-A.

4.26.04 Sufficient quantity of touch-up paint shall be furnished for application at site.

4.26.05 Caution notice plate shall be affixed at the back of each vertical panel.

5.00.00 **TESTS**

5.01.00 All equipment shall be completely assembled, wired, adjusted and tested at the factory as per the relevant standards.

5.02.00 **Routine Test**

The tests shall include but not necessarily be limited to the following :-

a. Operation under simulated service condition to ensure accuracy of wiring, correctness of control scheme and proper functioning of the equipment.

b. All wiring and current carrying part shall be given appropriate High Voltage Test.

c. Primary current & voltages shall be applied to all instrument transformers.

d. Routine test shall be carried out on all equipment such as circuit breakers, switch - fuse, contactors, relays, meters etc.

5.03.00 **Type Tests**

The type test certificates for the following tests carried out on an identical & similar type of switchgear shall be furnished. The date of tests shall be within the last five years.

a. Temperature rise Test

b. Short time current test on main circuit and earth circuit.

c. Verification of making and breaking capacity.

Type test certificates of any equipment shall be furnished if so designed by the purchaser/ owner. Otherwise the equipment shall have to be type tested free of charge, to prove the design. Type test performed before five (5) years are not acceptable.

6.00.00 **DRAWINGS, DATA & MANUALS**

6.01.00 Drawings, Data & Manuals shall be submitted in triplicate with the bid and in quantities and procedures as specified in General Conditions of Contract and/or elsewhere in the specification for approval and subsequent distribution after the issue of 'Letter of Intent'.

6.02.00 **To be submitted with the bid** :-

a. General arrangement drawing showing constructional features, space required in front for withdrawals, power & control cable entry points etc.

b. Typical foundation plan

c. Typical control schematic

d. Bill of materials

e. Type test reports on circuit breaker

f. Technical leaflets on :-
   i) Circuit breaker
   ii) Switch-fuse units
   iii) Contactors
   iv) Relays, meters, push buttons, selector switches etc.
   v) Glands/terminals blocks

6.03.00 **To be submitted for Owner / Purchaser's Approval and Distribution**

All relevant drawings and data pertaining to the equipment like GTP, GA drawing, foundation plan, BOM, control & schematics, QAP, etc. shall be submitted by the Bidder for approval of Owner/Owner's consultant. Also refer clause no. 1.19.02(u) of Section-I of Volume – V-A: Technical Specifications for Electrical Equipment & Accessories.

ANNEXURE-A

RATINGS AND REQUIREMENTS

1.0	General			
	Type	:	ACB Modules - Drawout type MCCB Modules – Drawout type	
	Service	:	Indoor	
	Enclosure	:	IP52	
2.0	System		AC	DC
	Voltage	:	415V ± 10%	220V (187-242V)
	Phase	:	3-phase, 4-wire	2- wire
	Frequency	:	50 Hz +3% to - 5%	
	Combined voltage and Frequency variation	:	10% (absolute sum)	
	System grounding	:	Solidly grounded	Ungrounded
3.0	Rating			
	Rated current	:	To be decided by the tenderers.	
	Design Ambient Temperature	:	50ºC	
	Short Circuit Current Symm.	:	50 KA	25* KA
	* Indicative only, the actual value will be decided by the tenderers.			
	S/C Withstand Time	:	---------- 1 second ----------	
	High voltage test for 1 minute	:	2.5 kV	1.5 kV
4.0	Duty			
	Circuit Breaker	:	0-3'-CO-3'-0	
	Contactor (AC)	:	Class III - Category AC3 for unidirectional drives and AC4 for bi-directional / inching duty drives	
	Contactor (DC)	:	Class I – category DC2	
	MCCB / Switch Duty for		AC	DC
	Motor Feeder	:	AC23	DC22

	Other Feeder	:	AC22 DC22
5.0	A.C. / D.C. Power Supply		
	Control Voltage for Circuit breaker	:	220V DC +10% to -15%
	Control voltage for MCCB modules	:	110V AC ± 10%, 1Ph, 50Hz +3% to - 5%
	Service voltage	:	240V AC ± 10%, 1Ph, 50Hz +3% to - 5%

ANNEXURE-B

PROTECTIONS

1.0 All Protective relays shall be numerical type having communication facility with Plant DDCMIS system / PLC.

2.0 The minimum protections to be provided for different types of circuits are listed below:

a.	Incoming Feeder & Bus-coupler with ACB :	3 -	inverse time O/C relays (51) for phase fault.
		1 -	Inverse time O/C relay (51N) for Earth fault.
		3 -	Under Voltage (27), Range : 40-80% with timer
b.	Motor Feeder with ACB: (above 110 kW)	1 -	Composite Motor protection relay (99) for protection against
		-	Thermal overload
		-	Phase faults
		-	Unbalance (negative sequence)
		-	Locked rotor
		-	Excessive Start-up time and Start-Stop.
		-	Earth fault
c.	Outgoing Feeder with ACB :	3 -	Inverse time O/C relays (51) for phase fault.
		1 -	Inverse time O/C relay (51N) for Earth fault.

3.0 Apart from protection relays, each electrically operated breaker shall be provided with anti-pumping (94), trip annunciation (30), lockout (86) and trip circuit supervision (74) relays. Lockout relay shall be hand reset type.

4.0 Both primary side & secondary side fuse failure / voltage loss monitoring system of VT shall be provided..

5.0 For Auto-bus change-over as well as live bus change-over through synchronization refer enclosed Control Schematic drawings.

6.0 Each incomer shall be provided with three (3) nos. Bus Energised indicating lamps – Red/Yellow/Blue for each phase.

ANNEXURE-C

FITTINGS & ACCESSORIES

Each switchboard shall be furnished complete with fittings and accessories as listed below: -

1. Operating mechanism complete with all accessories, fittings and tripping coil and closing coil, pole discrepancy feature etc. as required.
2. Base frame and anchor bolts and nuts.
3. Auxiliary contacts and relays.
4. LOCAL/REMOTE Selector switch, TRIP/CLOSE Push Buttons.
5. Manual tripping devices with protective flap.
6. Mechanical ON-OFF indicator.
7. Operation counters.
8. Set of switch fuse units/MCCB for A.C. and D.C. supply.
9. Space heater with thermostat and ON-OFF switch.
10. Cubicle illumination lamp with ON-OFF switch.
11. 3 Pin 5A Socket with ON-OFF Switch.
12. Terminal blocks and internal wiring - lot as required.
13. Other standard accessories which are not specifically mentioned but supplied with breakers of similar type and rating for efficient and trouble-free operation.

14. Bimetallic terminal connectors.

ANNEXURE-D

BUS TRANSFER SCHEME FOR PMCC

1.0 The manual bus transfer shall be arranged in such a way that any of the following modes of operation is possible.

1.1 **Manual Bus Transfer**

a) Without voltage interruption

This means by allowing momentary parallel operation of two sources.

b) With voltage interruption

i) Slow Transfer

ii) Fast Transfer

NOTE : For CHP/AHP system 'Manual bus transfer without voltage interruption' and 'dead bus transfer with voltage interruption' shall be provided.

Synchronization of Incomer & Bus coupler for each of the 415V PMCC shall be implemented through PLC in CHP electrical cum control room building. Synchronization check relay, guard relay and auxiliary relay shall be provided in each PMCC. Synchroscope along with cut off switch, double voltmeter, double frequency meter shall be provided in the Main CHP electrical building cum control room. Separate synchronization switch and trip selector switch for each of the PMCC shall also be provided in the CHP electrical building cum control room.

VOLUME: V-A

SECTION-VIII

TECHNICAL SPECIFICATION
FOR
LOCAL CONTROL BOARDS/PANELS,
LOCAL ISOLATING SWITCH UNITS
AND LOCAL PUSH BUTTON STATIONS

CONTENT

CLAUSE NO.	DESCRIPTION
1.00.00	SCOPE OF SUPPLY
2.00.00	CODES AND STANDARDS
3.00.00	DESIGN CRITERIA
4.00.00	SPECIFIC REQUIREMENTS
5.00.00	TESTS
6.00.00	DRAWINGS, DATA AND MANUALS

ATTACHMENTS

ANNEXURE-ARATINGS AND REQUIREMENTS	
ANNEXURE-B	A.C/D.C POWER SUPPLY
ANNEXURE-C	FUNCTIONAL REQUIREMENTS OF ANNUNCIATOR
ANNEXURE-D	AREA WISE INDICATIVE LIST OF LOCAL CONTROL BOARDS/PANELS
ANNEXURE-E	LOCAL CONTROL PANEL / LOCAL STARTER PANEL FOR COAL HANDLING PLANT

VOLUME: V-A

SECTION-VIII

TECHNICAL SPECIFICATION FOR LOCAL CONTROL BOARDS/PANELS, LOCAL ISOLATING SWITCH UNITS AND LOCAL PUSH BUTTON STATIONS

1.00.00 SCOPE OF SUPPLY

1.01.00 The following equipment shall be furnished with all accessories:

a) Complete set of Local Control Boards/Panels, an indicative list of which is given in Annexure-C

b) Local Push Button Stations: As required

c) Local Isolating Switch Units: As required

1.02.00 Furnishing, Mounting, and wiring of all equipments, devices and accessories

1.03.00 Floor Channel sill, vibration damping pad, and kick plates for all floor-mounted control boards/panels, complete with holding down bolts and nuts.

1.04.00 Mounting hardware for all control boards/panels, Local Push Button Stations, and Local Isolating Switch Units.

2.00.00 CODES AND STANDARDS

2.01.00 All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) and IEC except where modified and/or supplemented by this specification.

2.02.00 Equipment and material conforming to any other international standards, which ensure equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

2.03.00 The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

3.00.00 DESIGN CRITERIA

3.01.00 The Local Control Boards/Panels will be used for controlling incomers/ bus-section/electrically operated radial breaker feeders of the associated PMCC/MCC. Necessary indications, meters, annunciations and mimic representation shall also be provided on these control boards/panels.

Local control of all drives shall be done from Process Control Boards/Panels, as described in respective sections of mechanical specification.

The Local Control Boards/Panels shall have to be duly matched with the Process Control Boards/Panels.

3.02.00 Local Push Button (L.P.B.) stations will be used for controlling drives from local as required.

3.03.00 Local Isolating Switch (L.I.S) Units will be used for local isolation of power supply to various machines as required.

3.04.00 All equipment except L.I.S. Units and L.P.B stations, will be located in a clean but hot, humid, and tropical atmosphere. The L.I.S. Units and L.P.B. stations will be generally installed in a hot, humid, and tropical atmosphere, heavily polluted at places with fly ash and/or coal dust, and shall be suitable for outdoor service with degree of protection specified elsewhere in this specification.

3.05.00 All Control Boards/Panels, L.I.S. Units, and L.P.B. stations shall be liberally sized so as to provide spacious layout of equipment and devices with sufficient working space in between.

3.06.00 Adequate space/terminals shall be kept in the boards/panels for installing additional equipment in future.

3.07.00 For continuous operation at specified ratings, temperature rise of the various components/equipment shall be limited to the permissible values stipulated in the relevant standards and/or this specification.

3.08.00 All equipment/components thereof shall be capable of withstanding the mechanical forces and thermal stresses of the system short circuit current without any damage or deterioration of material.

3.09.00 Design, material selection, and workmanship shall be such as to present a neat appearance outside and inside with no welds, rivets, screws, or bolt heads apparent from the exterior surface of the boards/panels. All instrument cut-outs, mounting studs, and support brackets shall be accurately located.

4.00.00 SPECIFIC REQUIREMENTS

4.01.00 Construction

4.01.01 Local Control Boards/Panels

a) Local Control Boards may consist of a number of vertical panels mounted side-by-side, in each case, they shall be bolted together to form a compact unit. Where two panels meet, the joints shall be smooth, close-fitting, and unobtrusive.

b) The control boards/panels shall be totally enclosed type, conforming to degree of protection IP-54 or better.

c) Generally, the local control boards/panels shall be free-standing, floor-mounted, dead-front assemblies. In some cases, however, wall-mounted type control boards/panels may also be accepted.

d) Floor-mounted control boards/panels shall be assembled on channel/ angle base plates with anti-vibration mountings and stainless steel kick-plates.

e) All switchboard/panels frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness 2.0mm. Frames shall be enclosed in cold rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot/cold rolled sheet steel and 4.0 mm for non-magnetic material.

The boards/panels shall have sufficient structural reinforcement to ensure a plane surface, to limit vibration, and to provide rigidity during shipment and installation.

f) All floor-mounted panels shall have rear door.

g) Doors shall have concealed type hinges and padlocking arrangement. Doors shall be grounded by flexible copper braid.

h) All doors and removable covers shall be provided with neoprene rubber gaskets all round and latches sufficiently strong to hold them in alignment when closed.

i) Working height of the panels shall be limited between 550 mm and 1800 mm above floor level.

4.01.02 Local Push Button Stations

a) L.P.B. Stations shall be furnished in sheet steel enclosure of dust and vermin-proof, weather-proof, gasketted construction, suitable for outdoor use without canopy, and conforming to degree of protection IP-55 or better for indoor and IP-65 for outdoor.

b) L.P.B. Stations shall be suitable for column/structure/wall mounting and shall be complete with push-buttons, terminal blocks, anodised aluminum inscription plate, two (2) nos. earthing terminals, removable gland plate along with crimp type tinned copper lugs and compression type glands for cable/conduit entry from top and bottom. The earthing terminals shall be suitable for connection to one (1) no. 8 SWG G.I. wire.

c) L.P.B. Stations shall be of the following basic type and equipped with:

Type-A	:	One (1) START push-button and one (1) STOP push-button.
Type-B	:	One (1) OPEN push-button, one(1) CLOSE push-button, and one(1) STOP push-button.

Type-C	:	Flame proof type as per IS-2148. one (1) START push-button and one(1) STOP push-button.
Type-D	:	One (1) STOP Lock-out switch.
Type-E	:	One (1) STOP Emergency PB.

Belt sway bridging Push Button shall be provided in the Local Push Button Station for all conveyor Drives.

Emergency Stop push button shall be provided in the Local Push Button Station for all HT motors.

Any other type of L.P.B. Station, if required, shall be subject to approval of the Purchaser.

d) OPEN, CLOSE, and START push-buttons shall be spring return to normal type. STOP push-buttons shall have mushroom head actuator with press-to-latch and key-to-release feature.

e) OPEN/START push buttons shall be GREEN, STOP push buttons shall be RED, and CLOSE buttons may be YELLOW.

f) All push-buttons shall have a minimum of two (2) Normally-Open and two (2) Normally-Closed electrically separate contacts, rated minimum 10 A at operating voltage.

g) Wiring shall be done with 1100V grade fire resistance PVC insulated stranded copper conductor of not less than 2.5 Sq.mm cross section. Each wire shall be identified at both ends by ferrules with wire designation.

h) Terminals shall have provision for connecting at least two (2) nos. 2.5 sq.mm. Copper cable and shall be rated for carrying continuously minimum 10 A at 240V A.C. and 2 A at 220V D.C.

4.01.03 Local Isolating Switch Units

a) L.I.S. Units shall be furnished in sheet steel enclosure of dust and vermin-proof, weather-proof, gasketted construction, suitable for outdoor use without canopy, and conforming to degree of protection IP-55 or better.

b) L.I.S. Units shall be suitable for column/structure/wall mounting and shall be complete with load-break switch, terminal blocks, anodised aluminum inscription plate, two (2) nos. earthing pads, removable gland plate along with crimp type tinned copper lugs and compression type glands for cable/conduit entry from top and bottom. The earthing pads shall be suitable for connection to 25 x 3 mm G.S. flat

c) Load-break switches shall be four-pole, air break, heavy-duty type. Duty class of load-break switches shall be AC-23 for motor feeders. Motor feeder switches shall be capable of safely breaking the locked rotor current of the associated motor circuit.

d) Terminals shall be clip-on type, 10 sq.mm. minimum.

4.02.00 **Equipment Mounting**

4.02.01 All equipment shall be so mounted that removal and replacement may be accomplished individually without interruption of services to others. No equipment shall be mounted on panel door.

4.02.02 All equipment mounted inside the panels shall be so located that their terminals and adjustments are readily accessible for inspection or maintenance.

4.02.03 For Local Control Boards/Panels control components such as push buttons, indicating lamps, selector switches, indicating meters etc. shall be flush mounted on the front face of the board/panel while switch fuses, supervision relays (AC/DC) etc. shall be mounted inside.

4.03.00 **Name Plate**

4.03.01 Nameplates shall be furnished for each panel and for each instrument or device mounted on the panel. Each LPB Station shall also be provided with a nameplate.

4.03.02 The material of the nameplate shall be lamicoid or approved equal, 3 mm thick, with white letters on black background.

4.03.03 The nameplates shall be held by self tapping screws. The size of nameplate shall be approx. 20 mm x 75 mm for equipment and 40 mm x 150 mm for the panels. The size of the nameplate shall suit the overall dimensions of LPB station/L.I.S Unit.

4.03.04 Nameplates for panels shall be provided both on the front and on the rear and shall be according to final device/designation list.

4.03.05 Control and meter selection switches shall have integral nameplates. Nameplates for all other devices shall be located below the respective devices.

4.03.06 Instruments and devices mounted on the face of the panels shall also be identified on the rear with the instrument or device number. The number may be painted on or adjacent to the instrument or device case.

4.04.00 **Mimic Diagram**

4.04.01 Mimic diagram of electrical connections shall be furnished on the front face of all electrical control panels.

4.04.02 Mimic buses shall be at least 3 mm thick and 10 mm in width, made of suitably treated metal strips or approved equivalent and colour coded to denote different voltages.

4.04.03 The mimic representation, colour and size of diagram are subject to the approval of the Purchaser.

4.05.00 **Illumination, Space Heating and Receptacles**

4.05.01 Each panel shall be provided with interior fluorescent tube with door switch, space heater with thermostat and 5A, 5-pin receptacle with plug. Fifth pin of the socket shall be effectively grounded through the metallic structure.

4.05.02 Tube, heater and receptacle circuits shall be suitable for available A.C. supply and furnished with individual ON-OFF switch.

4.05.03 The lamp shall be located at the ceiling and guarded with protective cage. Space heater shall be located near the floor so as not to pose any hazard to service personnel.

4.06.00 **AC/DC Power Supply**

4.06.01 Necessary A.C. and D.C. supplies as required for control and service shall be arranged by the contractor. Single feeder shall be arranged for A.C supply and duplicate feeders shall be arranged for D.C supply.

4.06.02 Isolating switch fuse units shall be provided for the incoming AC/DC power supplies and bus wires shall be run for power distribution to different panels. D.C. supply isolating switches shall be double pole, double throw with off and A.C. supply isolating switches shall be 4-pole, double throw type.

4.06.03 Fuse and link shall be provided for individual circuits for protection and also for isolation from bus wire without disturbing other circuits.

4.06.04 The fuse requirements in each panel shall be grouped in easily accessible fuse blocks or distribution panel. The grouping shall be done in a neat and orderly fashion.

4.06.05 Alarm relays with reverse flag shall be provided to annunciate failure of main incoming A.C. and D.C. power supplies and annunciation D.C. supply in each panel. Lamp indications shall be provided individually for main D.C. supply-1 fail, main D.C. supply-2 fail, and panel annunciation D.C. supply fail. A common A.C. electric bell shall be provided to give an audible alarm in case of failure of D.C. supply-1/D.C. supply-2/annunciation D.C. supply in any panel. A common push-button shall also be provided for cancellation of lamp indications and audible alarm.

4.06.06 Separate circuits shall be provided for (a) indication and alarm (b) tripping, and (c) control.

4.06.07 For lighting, auxiliary supply and space heating A.C. supply shall be used. D.C. supply shall be used for providing control supply to annunciator.

4.06.08 Bus wires of adequate capacity shall be provided to distribute the incoming supplies to different cubicles of a VDB. Isolating switch fuse units shall be provided at each cubicle for A.C/D.C supplies.

4.07.00 **Wiring**

4.07.01 The panels shall be fully wired up at the factory to ensure proper functioning of control, protection and metering schemes.

4.07.02 All spare contacts of relays and switches shall be wired up to terminal blocks.

4.07.03 Wiring shall be done with 1100V grade fire resistance PVC insulated stranded copper conductor of not less than 2.5 Sq.mm cross section for current control circuits and voltage circuits.

4.07.04 Each wire shall be ferruled by plastic tube with indelliable ink print at both end having terminal Block No., terminal numbers, destination number as per approved wiring drawing.

4.07.05 All wire termination shall be made with insulated sleeve solderless crimping type tinned copper lugs. Wires shall not be tapped or spliced between terminals.

4.07.06 Wiring shall be neatly bunched in groups by non-metallic cleats or bands. Each group shall be adequately supported along its run to prevent sagging or strain on the termination.

4.07.07 Colour codes shall be used for wiring as per latest revision of IS: 375.

4.08.00 **Terminal Block**

4.08.01 Multi-way terminal blocks complete with necessary binding screws and washers for wire connections and marking strip for circuit identification shall be furnished for terminating the panel wiring and outgoing cables. Terminals shall be box-clamp type, 10 sq.mm. minimum. Terminals for C.T. secondary leads shall have provision of shorting and grounding.

4.08.02 Not more than two wires shall be connected to one terminal. If necessary, a number of terminals shall be jumpered together to provide wiring points.

4.08.03 Each terminal shall be identified with designation as per approved schematic. At least 20% of the total number of active terminals shall be furnished as spare in each panel.

4.08.04 The wiring and terminals shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.

4.08.05 The terminal blocks shall be located to allow easy access and also to suit floor openings for cable entry.

4.08.06 The terminal blocks within the panels shall be mounted on vertical support brackets. The support brackets shall be tack welded to the interior sheet steel mounting plates of the cabinet. Support brackets shall not be welded directly to the walls of the enclosure. The terminal blocks shall be attached to the support brackets with round head machine screws.

4.08.07 Terminal blocks shall generally be mounted vertically with adequate spacing (not less than 100 mm) between adjacent rows.

4.08.08 The bottom of the terminal block shall be at least 200 mm above the incoming cable gland plate.

4.09.00 **Cable Entry**

4.09.01 The Control Boards/Panels shall have provisions of cable entry from the bottom. Bottom plate shall be provided to make entry dust-tight. L.P.B. stations and Local Isolating Switch Units shall have provision for cable/ conduit entry from both top and bottom. Suitable cable gland-plates shall be provided.

4.10.00 **Grounding**

4.10.01 50 x 6 mm GI ground bus shall be provided in each control panel extending along the entire length of the assembly.

4.10.02 The ground bus shall have two-bolt drilling with GI bolts and nuts at each end and shall be suitable for connection to 50 x 6 mm G.S. flat.

4.10.03 The ground bus shall be bolted to the panel structures and shall effectively ground the entire assembly. The cases of meters, relays and switching devices shall be grounded through the steel structure.

4.10.04 Whenever a circuit is grounded, a single wire from the circuit shall be run independently to the ground bus and connected to it.

4.11.00 **Painting**

4.11.01 For paint shade finish, refer Section-X of Volume: II-A : Lead Specification.

4.11.02 Caution Notice plate shall be affixed at the back of each vertical panel.

4.12.00 **Switches**

4.12.01 Switches shall be dust protected, heavy duty, switchboard type, complete with escutcheon plate. Contacts shall be silver surfaced and rated minimum 10A at operating voltage.

4.12.02 415V Breaker control switches shall be 3-position (TRIP/NORMAL/-CLOSE), 120^{o}, spring return to neutral with lost motion device, non-lockable, sequence device, pistol grip handle. RED/AMBER/GREEN (circuit breaker CLOSED/ TRIPPED-OR-TRIP CIRCUIT UNHEALTHY/OPEN) indicating lamps shall be provided with each breaker control switch.

4.12.03 Contact details and type of handle required for other types of switches are given below :

Sl. No.	Application	Switch description
a)	Synchronizing Selector switch	180^{o}, 4-position (INCOMER-1/ BUS-SECTION / INCOMER-2/OFF), stay put type, pistol grip handle. OR

		120°, 3-position (INCOMER/TIE/ OFF) stayput type, pistol grip handle.
b)	Trip Selector Switch	120°, 3-position (INCOMER-1/ BUS-SECTION OR TIE/ INCOMER-2), stayput type, pistol grip handle.
c)	Meter Selector Switch	4-position (OFF/R/Y/B for ammeter selector switch and OFF/RY/YB/RB for voltmeter selector switch), maintained contact, stay-put type, knob handle. Ammeter selector switches shall have make-before- break contacts.
d)	Auto-Manual Selector switch	120°, 2-position (AUTO/ MANUAL), stayput type, non-lockable, spade handle.
e)	On-off Switch/Local-Remote Selector Switch	90°, 2-position (ON/OF OR LOCAL/ REMOTE), stayput type, non-lockable, spade handle

4.12.04 Any other type of switch, if required, shall be subjected to approval of purchaser.

4.12.05 Tenderer shall decide the number of switch contacts taking into account the scheme requirements and spares.

4.13.00 **Fuses**

4.13.01 Fuses shall be HRC, preferably link type, with a minimum interrupting capacity equal to the system short circuit current.

4.13.02 Fuses shall be furnished complete with fuse boxes and fittings of such design as to permit easy and safe replacement of fuse element. Visible indication shall be provided on blowing of the fuse.

4.13.03 Motor fuse characteristics and ratings shall be chosen to ride over motor starting period without blowing. The fuse on incoming feeder, wherever provided, shall be chosen to provide discrimination with motor/feeder fuses.

4.14.00 **Contactors**

4.14.01 Contactors shall be three pole, air break type, with non-bouncing silver/silver alloy contacts. Contactor duty shall be class III - category AC3 for unidirectional drives and AC4 for bi-directional and inching drives/class I - category DC2.

4.14.02 Each contactor shall be provided with minimum two (2) N/O and two (2) N/C auxiliary contacts rated 10 A at operating voltage. The exact requirement of

contacts shall be decided by the Tenderers taking into account the scheme requirements and spares.

4.14.03 Contactor starters shall comply with the requirements of IS-8544 (Part - 1) in respect of co-ordination of the characteristics of contactor, overload relay, and fuse. The type of co-ordination shall be Type-C as per IS-8544.

4.15.00 **Thermal Overload**

4.15.01 Thermal overload relays shall be three elements, positive acting, ambient temperature compensated with adjustable settings.

4.15.02 Single phasing preventor shall be provided as an inbuilt feature of the thermal overload relay.

4.15.03 Overload relays shall be manual reset type with change over contacts. Resetting of relays shall be possible with compartment door closed. Colour of resetting button shall be BLACK.

4.15.04 Relays for fan motors having long starting time shall be saturable core C.T. operated.

4.16.00 **Current Transformers**

4.16.01 Current transformers shall be cast-resin type. All secondary connections shall be bought out to terminal blocks where wye or delta connection will be made.

4.16.02 Accuracy class of the current transformers shall be:

a) Class PS for differential.

b) Class 5P20 for other relaying.

c) Class 1.0 ISF < 5 for metering.

Other CT particulars like ratio, burden, knee point, excitation current & secondary resistance shall be decided by the tenderers.

4.16.03 Drives requiring current monitoring shall be provided with current transducers with calibration for full-scale reading. The output shall be 4-20 mA D.C; 4-18mA of which shall correspond to the normal range and 18-20 mA shall correspond to the suppressed range.

4.17.00 **Voltage Transformers**

4.17.01 Voltage transformers shall be cast-resin, drawout type and shall have an accuracy class of 1.0.

4.17.02 High voltage windings of voltage transformer shall be protected by current limiting fuses. The voltage transformer and fuses shall be completely disconnected and visibly grounded in fully draw out position.

4.17.03 Secondary winding MCBs, sized to prevent overload shall be installed in all ungrounded secondary leads. MCBs shall be suitably located to permit easy replacement while the switchgear/PMCC is energized.

4.17.04 Both primary side & secondary side fuse failure / voltage loss monitoring system of VT shall be provided.

4.18.00 **Push Button**

4.18.01 All push buttons shall be oil tight, heavy duty, push to actuate type, with coloured button and inscription plate marked with its function. The colour of "ON" and "OFF" push buttons shall be RED and GREEN respectively. RESET push buttons shall be coloured black.

4.18.02 Each push button shall have minimum 2 NO. + 2 NO. contacts, rated 10A at 240V AC and 2A at 220V DC.

4.18.03 Push buttons shall be shrouded type except for emergency trip button, which shall be mushroom type for easy identification.

4.19.00 **Lamps**

4.19.01 Lamps shall be LED type.

4.19.02 LED lamp shall be made in accordance with InP Technology (Aluminium Indium Gallium Phosphide Technology). The body shall be made of Poly Carbonate Unbreakable Lens. LED shall be protected by inbuilt fuse with surge suppressor or leakage voltage glow protection. LED circuit shall be PCB mounted. Intensity shall be greater than 200 mcd. All Push Button lamp shall be as per LED indicating lamp.

4.20.00 **Operating Range**

All instruments shall be generally suitable for operation on 1A or 5A C.T. secondary circuit and/or 110V V.T. secondary circuit.

4.21.00 **Meters**

4.21.01 All indicating instruments shall be switchboard type, back connected, suitable for flush mounting, 96 x 96 mm with 240 Deg. scale, antiglare glass and accuracy class of 0.5. The dials shall be made of such material as to ensure freedom from warping, fading, and discolouring during the lifetime of the instruments.

4.21.02 All indicating instruments shall be enclosed in dust-tight cases suitable for tropical use.

4.21.03 Meters shall have provision for zero-adjustment from front of the panel.

4.21.04 Meters shall be compensated for temperature errors and factory calibrated to read the primary quantities directly without using a multiplying factor.

4.21.05 D.C. ammeters, wherever required, shall be provided with external shunt if the current exceeds 5A. The rated voltage drop for the shunts shall be 75mV.

4.22.00 **Annunciator System**

4.22.01 Each control panel shall be provided with an annunciator window board. The annunciator boards shall be back-connected and suitable for semi-flush mounting.

4.22.02 The annunciator system shall be solid state type with optical isolation for input signals. The functional requirements shall be as per Annexure-C.

4.22.03 Each annunciator group shall be independent, complete with its own power supply, acknowledge-reset-test buttons and other necessary accessories. Hooter for audible alarm shall be common for each control panel assembly.

4.22.04 Each annunciator group shall be provided with a common alarm relay for group alarm annunciation in remote control room. The common alarm relay will operate on actuation of any alarm point of the group.

4.22.05 The annunciator shall be non-integral type with hardware box mounted separately for easy access and maintenance.

4.22.06 Audible alarms with different tones shall be used for trip, non-trip and ring back functions.

4.22.07 The window size shall be such as to accommodate minimum three (3) lines of twelve (12) characters each. Each character shall be minimum 4.75 mm high.

4.22.08 The annunciator system shall be suitable for operation from both NO and NC type initiating contacts.

4.22.09 At least 10% spare channels and window facia shall be provided in each annunciator group.

4.23.00 **Relays**

4.23.01 Auxiliary relays shall be furnished in fixed, dust-tight, casings and mounted inside the panel.

4.23.02 The relays shall have adequate numbers of contacts to suit scheme requirements. Besides, each relay shall have spare contacts for future use.

4.23.03 Contacts shall be silver-surfaced, bounce-free, and capable of repeated operation without deterioration.

4.24.00 **Auxiliary Devices**

4.24.01 The Contractor shall furnish, install, and wire-up all auxiliary devices such as timing / switching / lockout / auxiliary relays/auxiliary contactors, etc. as required for the proper functioning of the approved schemes.

4.24.02 The Contractor shall number the various types of relays and contactors as per the numbers appearing in the approved Schematic/Wiring appearing in the approved Schematic/Wiring diagrams.

5.00.00 **TESTS**

5.01.00 All Control Boards/Panels, L.I.S. Units and L.P.B. Stations shall be completely assembled, wired, adjusted and tested at the factory prior to shipment to ensure accuracy of wiring, correctness of control scheme and proper functioning of all components.

5.02.00 **Routine Tests**

5.02.01 The tests shall include wiring continuity tests, high voltage tests, interlock & sequential operation test, insulation measurement test both before and after high voltage test, and functional tests to ensure accuracy of wiring operation of the control/ protection/metering schemes and individual equipment. Detailed test report including procedure and drawing shall be furnished.

5.02.02 All switches, meters, relays and other devices shall be tested and calibrated in accordance with relevant IS standards.

5.03.00 Type test certificate on any equipment, if so desired shall be furnished. Otherwise the equipment shall have to be type tested, free of charge, to prove the design.

6.00.00 **DRAWINGS, DATA & MANUALS**

6.01.00 Drawings, Data & Manuals shall be submitted in triplicate with the bid and in quantities and procedures as specified in General Conditions of Contract and/or elsewhere in the specification for approval and subsequent distribution after the issue of 'Letter of Intent'.

6.02.00 **To be submitted with the Bid**

6.02.01 General Arrangement drawings and cross-section of each equipment showing constructional features, cable entry points etc.

6.02.02 Typical foundation plan.

6.02.03 Bill of Materials.

6.02.04 Technical leaflet and Catalogues of:

a) Local Control Boards and Local Starter-cum-Control panels

b) Local Isolating switch units

c) Local Push Button Stations

d) Switches and Lamps

e) Meters, relays, push buttons

f) Switch fuse units

g) Annunciator System

h) Auxiliary Devices

i) Terminal Blocks/glands.

j) Temperature Scanner

6.02.00 **To be submitted for Owner / Purchaser's Approval and Distribution**

All relevant drawings and data pertaining to the equipment like GTP, GA drawing, foundation plan, BOM, control & schematics, QAP, etc. shall be submitted by the Bidder for approval of Owner/Owner's consultant. Also refer clause no. 1.19.02(u) of Section-I of Volume – V-A: Technical Specifications for Electrical Equipment & Accessories.

ANNEXURE-A

RATINGS & REQUIREMENTS

1.0	Local Control Board		
1.1	General		
	Type	:	Fixed type
	Service	:	Indoor
	Enclosure	:	IP-54
1.2	System		
	Voltage	:	415 Volt ± 10%
	Phase	:	3
	Frequency	:	50 Hz +3% to -5%
	System	:	Solidly grounded
1.3	Rated Current at 50°C		
	Bus bar	:	To be decided by the Tenderers
	Switches	:	To be decided by the Tenderers
1.4	Short Circuit Rating		
	Interrupting	:	50 kA
	Short time for 1 Second	:	50 kA
1.5	Insulation Level	:	2.5 kV for 1 min.

ANNEXURE-B

A.C./D.C. POWER SUPPLY

1.0 **System Voltages**

All systems shall be designed for satisfactory operation from the following power supply :-

A.C. Supply	:	240 Volt, 1 Phase, 50 Hz, 2 wire, effectively grounded system.
		Fault level 50 kA rms Symmetrical.
D.C. Supply	:	220V, 2 Wire, ungrounded.
		Fault level 25* kA

* Indicative only actual value will be decided by the Bidder, after substantiating the same by calculation.

2.0 **Permissible Variation**

Equipment and accessories shall be suitable for operation over the entire range of voltage/frequency variation as listed below :

A.C. Supply:

Voltage	:	± 10%
Frequency	:	+3% to -5%
Combined Volt & Freq.	:	10% (absolute sum)

D.C. Supply:

Voltage	:	187 to 242
Service Voltage for Control Panels/ Distribution Boards	:	240V ± 10%, 1ph, 50Hz +3% to -5%

ANNEXURE-C

FUNCTIONAL REQUIREMENTS OF ANNUNCIATOR

TYPE

The annunciation system shall be manually reset type with ring back facility, suitable for operation from 220V DC ungrounded supply.

FUNCTION

The sequence of operation shall be similar to ISA-2A with fast/slow blinking as detailed below:

Field Condition	Visual Display	Audible Alarm	Ringback Alarm
Normal	Off	Silent	Silent
Abnormal	Fast blinking	On	Silent
Acknowledge	Steady On	Silent	Silent
Return to normal	Slow blinking	Silent	On
Reset	Off	Silent	Silent
Normal Before Acknowledge	Slow blinking	On	On
Acknowledge	Steady On	Silent	On
Reset	Off	Silent	Silent
Test	Fast blinking	On	On

ANNEXURE-D

AREA WISE INDICATIVE LIST OF LOCAL CONTROL BOARDS

Sl. No.	Description
1.	C.W. System Electrical Control Board
2.	Electrical Control Board for MCC/PMCC located in Ash-Slurry and Ash-Water Building.
3.	Electrical Control Boards for ESP PCC/PMCC
4.	Electrical Control Board for Fuel Oil Pressurizing system
5.	Electrical Control Board for Fuel Oil Unloading and Forwarding MCC
6.	Electrical Control Boards for Raw water MCC
7.	Electrical Control Boards for Hydrogen generation plant

Note: The above list is indicative only. The above boards shall be hooked-up to respective system PLCs. In addition to the above Electrical Control Boards, necessary local panels/remote panel shall be provided for respective system/equipment/drive, e.g., BFP, Hydrogen-seal Oil system for Generator, ESP, etc. as described in respective sections of mechanical specification.

ANNEXURE-E

LOCAL CONTROL PANEL / LOCAL STARTER PANEL FOR COAL HANDLING PLANT

1.00.00 **DESIGN CRITERIA**

1.01.00 **Stacker/Reclaimer MCC & Control Desk**

The power supply from 3.3 kV CHP switchgear shall be achieved through one (1) number land mounted load break isolator, one (1) number fuse cum junction box located near centre or travel, one (1) number machine mounted load break isolator, line P.T with voltmeter on 3.3 kV side, L.T Air Circuit Breaker, Ammeter with selector switch, Voltmeter with selector switch etc.

Power CRD shall be connected to isolator panel mounted on the machine. H.T. fuses for the primary side of the transformer shall be housed inside the isolator panel on machine. Fuses shall be provided with the striker pin mechanism. Specification of Load break isolator is governed by HT Switchgear Specification

1.01.01

a) One number Stacker-Reclaimer MCC shall be provided on the mobile Stacker-Reclaimer. This MCC shall receive power at 433V, 50 Hz, from the output of a 3.3 kV/433V, dry type cast resin power transformer located on the mobile machine, through suitable cables.

b) Power shall be received at the panel by means of ACB unit. The ACB shall be series trip type with short circuit and ground fault releases having adjustable settings. Necessary CT ammeter, ammeter selector switch; voltmeter; voltmeter selector switch; R/Y/B indication lamps shall be available on the MCC. Power supply for indication of breaker including load break isolator shall be derived from the UPS of PLC. The specification requirement of MCC is guided by respective 415V PMCC/MCC specification.

c) Stacker/Reclaimer is PLC controlled. Under manual local operation it shall only be possible to run individual equipment by passing all process interlock. Under manual remote operation it shall be possible to run the entire system through PLC with process and safety interlock in place. The selector switch, remote/local shall be housed in control desk.

d) Specification requirement of PLC has been detailed under main PLC specification with the exception of 100% hot standby mode and redundancy.

e) Control desk shall accommodate annunciation windows, selector switches, ammeter, voltmeter and indicating lamps for incomer, ammeter for outgoing motor feeder rated 30 kW and above.

f) Panel door shall be interlocked with the incoming switch such that the panel door can not be opened when the switch is `ON'. However, necessary door interlock defeat feature shall also be provided for

testing purpose. Rating of components shall conform to the rating indicated in the enclosed component selection chart.

g) Audio visual annunciation system shall have at least but not limited to the following annunciation points complete with Accept/Test Preset P.B.:

i) Transformer winding temperature high.
ii) 415 V Incomer breaker tripped
iii) Boom Conveyor zero speed switch operated
iv) Boom Conveyor belt sway operated
v) Boom Conveyor pull cord switch operated
vi) Boom Conveyor brake not released.
vii) Boom Conveyor Motor overload/SPPR fault
viii) Back up limit switch operated.
ix) Wind velocity high.
x) Wind velocity very high.
xi) Slew limit switch operated.
xii) Slew drive fault.
xiii) Slew motor overload.
xiv) Slew drive lubrication system fault.
xv) Hydraulic oil temperature high.
xvi) Oil level low in hydraulic tank.
xvii) Hydraulic system filter clogged.
xviii) Bucket wheel brake not released.
xix) Bucket wheel zero speed switch fault.
xx) Bucket wheel motor overload/SPPR fault.
xxi) Power CRD motor overload.
xxii) Power CRD over tension switch operated.
xxiii) Control CRD motor overload.
xxiv) Control CRD over tension switch operated.
xxv) Travel drive brake not released.
xxvi) Travel drive motor overload/SPPR fault.
xxvii) Travel limit switch operated.
xxviii) Rail clamp not released.
xxix) DS motor overload/SPPR fault (to be provided for each motor).
xxx) HT load brake switch operated.

Annunciation system shall be similar to that of main Control Panel with 20% spare windows.

h) Separate cable reeling drum shall be provided for power & control cable. Combined trailing cable shall have 24C X 2.5 mm^2 (cu) control cable and 8 pair 1.5 mm^2 (cu) screened cable for signal and communication.

1.02.00 ON/OFF operation of Wagon tipplers shall be achieved from the respective Wagon tippler Control desk through PLC based logic. Control desk shall be provided in each Wagon tippler Control room for Control, Operation, Indication & Annunciation of Wagon Tippler equipment. Control desk shall interface with PLC for the entire operation and shall accommodate annunciation windows, ammeter, voltmeter, selector switches and indicating lamps for incomer, ammeter for outgoing motor feeder rated 30 kW and above. Other features as described above for the control desk of Stacker Reclaimer shall also be considered for Wagon Tippler.

1.03.00 MCC/DB/Local Starter Panel for Dust Suppression, Dust Extraction, Sump Pump, Coal Sampler, Bunker Level and other Panels

1.03.01 The Local Starter Panel shall be fixed type with compartmentalized execution. One (1) number 415 V ± 10% 3 phase 4 wire 50 Hz +3% to -5% power supply feeder shall be provided for each panel. Power shall be received through an incoming SFU having R/Y/B indication lamps, voltmeter with selector switch, ammeter with selector switch. Individual motor feeder shall have their switch fuse, power contactor, overload relay-cum-single phasing preventor (hand reset type), stop/ start push button, auto/manual selector switch, Red/Green/ Trip indication lamp, auxiliary relays, timers, etc. The stop push button shall be lockable type. Necessary interlock, annunciation, 415/240 V Transformers for control supply, space heating as applicable to meet system requirement shall also be provided and in no case derive any power supply from its main feeder. Separate feeders shall also be provided for brakes and rail clamp as applicable. Facility shall be provided for resetting the motor overload relay from outside without opening the panel door. Panel door shall be interlocked with the incoming Switch such that the door can not be opened when Switch is ON.

Specification requirement of the above including module selection chart will be governed by 415 V MCC/PMCC Specification.

1.03.02 Interlock, control, indication, annunciation etc. shall be achieved by relay logic

1.03.03 Isolation of individual circuit in the MCC/DB/Local Starter Panel shall be provided through individual Fuse.

1.03.04 Control features as described under relevant mechanical section shall be considered for interlocking and preparation of control schematic.

1.03.05 Thermostatically control space heater shall be provided.

1.03.06 Necessary door interlock defeat feature shall also be provided for testing purpose. Wherever necessary, the panels shall be designed for outdoor and of weather proof/rain protection type. Ratings of components shall be as per module selection chart indicated under 415 V PCC/PMCC/MCC Specification.

1.03.07 **Travelling Tripper DB cum Control Panel**

In addition to indication to be provided for drives, following indications shall also be provided in local panel:

i) Brakes applied
ii) Rail clamps applied
iii) Flap Gate position
iv) Travel driver over speed
v) Travelling tripper – Forward/Reverse
vi) Cable Reeling Drum on

Travelling tripper position on bunker shall be provided in the PLC.

Control features as described under relevant mechanical portion shall be considered for interlocking and preparation of control schematic.

Cable reeling drum shall be provided for power & control cable. Apart from meeting the requirements in respect of control , indication & annunciation and telecommunication following spare cores shall be provided:

i) 4 pair core (Sheilded) for communication.
ii) 4 Core for control.

1.03.08 **Sump Pump Control Panel**

Sump Pump Control Panel shall be provided with level controller, necessary contacts to start pumps in auto mode when level reaches high. Further, very high level shall cause hooter to blare and the same shall stop after sometime delay. In manual mode it shall be possible to start individual pump. However, in manual mode and auto mode of operation, pump shall be tripped when level in the sump pit reaches low. Sump pumps shall be able to operate from PLC, the level switches shall be wired to PLC.

In addition to other indicating lamps level high indication lamp shall also be provided in local panel.

1.03.09 **Miscellaneous Control Panels**

Miscellaneous control panel i.e. dust suppression panel, ventilation panel, etc. shall have individual starter feeder for individual drive. Other features as specified above shall also be provided. Equipment such as Vibrating Grizzle feeders, Magnetic separators, Metal detectors, Dust suppression, Ventilation, Dust extraction, Coal Sampler, Bunker Level, Hoists etc. shall have individual starter-cum-control panels to suit individual requirements. The panels shall include all necessary feeders, start stop PB, indicating lamp, annunciation system, 415/240V control transformers for control supply and space heating as applicable to meet system requirement. For Magnetic Separators, separate panels shall be provided. One panel shall accommodate transformer & rectifier and the other panel shall accommodate incomer and other controlling items.

The requirement of 4-20 mA signals for Belt Weigher and bunker level indicator have been spell out in Mechanical Specification and accordingly the same shall be provided.

2.00.00 SPECIFIC DESIGN REQUIREMENT

2.01.00 Construction

a) Stacker/Reclaimer/ Wagon Tippler Control Desk

Ammeters and annunciation facia shall be mounted on the vertical portion of the panel and all push button; selector switches; indication lamps etc. shall be mounted on the desk portion. The front desk shall be with top inclined downward towards front. A removable type front door shall be provided on the desk portion along with a lockable and lift-off rear door for the panel portion of the desk-cum-panel.

Travelling Tripper/Magnetic Separator/Metal Detector/Dust Extraction/ Dust Suppression/Ventilation/Coal Sampler/Bunker Level indication, Hoist/MCC/DB/Starter-Cum-Control Panel, Misc. Control Stations, Push Button Stations & Local Information Boards.

These panels/stations shall be furnished in sheet steel enclosures suitable for wall/column/floor mounting.

2.02.00 General

a) Design, material selection and workmanship shall be such as to present a neat appearance outside and inside with no marks of welds, rivets, screws or bolt heads apparent from the exterior surface of the frames.

b) Panels shall be of folded sheet steel construction, assembled on channel/angle base plates. Anti-vibration mountings shall be provided for moving equipment.

c) All switchboard/panel frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness 2.0mm. Frames shall be enclosed in cold rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot/cold rolled sheet steel and 4.0 mm for non-magnetic material. The panels shall have sufficient structural reinforcement to ensure a plain surface, limit vibration and provide rigidity during despatch and installation. Vertical panels shall be freestanding type.

d) Sufficient inter-component spacing shall be available for easy maintenance, replacement, ventilation etc. of the components. A minimum spacing of 50mm is recommended for the same.

e) All doors, covers etc. shall be properly gasketted to make the panel effectively vermin and dust proof. Door hinges shall be concealed

type. Special dust protection measures shall be taken for panels located in dusty area.

f) All hardware for the complete installation of the equipment including foundation and fixing bolts, nuts, washers etc. shall be supplied to suit the requirement. All bolts, nuts etc. exposed to external atmosphere shall be cadmium plated or zinc passivated.

g) The panels shall be liberally sized so as to provide spacious layout of equipment and devices with sufficient working space in between.

h) Shock absorbers shall be provided for panels mounted on mobile machines.

i) Maximum and minimum height of the operating devices on all panels except Local Control Stations shall be restricted to 1800 mm and 750 mm respectively from the floor level.

VOLUME: V-A

SECTION-II

TECHNICAL SPECIFICATION
FOR
A.C. & D.C. MOTORS

CONTENT

CLAUSE NO.	DESCRIPTION
1.00.00	SCOPE
2.00.00	CODES & STANDARDS
3.00.00	SERVICE CONDITIONS
4.00.00	TYPE AND RATING
5.00.00	PERFORMANCE
6.00.00	SPECIFIC REQUIREMENTS
7.00.00	ACCESSORIES
8.00.00	TESTS
9.00.00	DRAWINGS, DATA & MANUALS

ATTACHMENT

ANNEXURE-A	DESIGN DATA

VOLUME: V-A

SECTION-II

TECHNICAL SPECIFICATION FOR A.C. & D.C. MOTORS

1.00.00 **SCOPE**

1.01.00 This section covers the general requirements of the drive motors for power station auxiliary equipment.

1.02.00 Motors shall be furnished in accordance with both this general specification and the accompanying driven equipment specification.

1.03.00 In case of any discrepancy, the driven equipment specification shall govern.

2.00.00 **CODES & STANDARDS**

2.01.00 All motors shall conform to the latest applicable IS, IEC and CBIP Standards/ Publications except when otherwise stated herein or in the driven equipment specification.

2.02.00 Major standards, which shall be followed, are listed below other applicable Indian Standards for any component part even if not covered in the listed standards shall also be followed:

i) IS-325

ii) IS-12615

iii) IEC-60034

3.00.00 **SERVICE CONDITIONS**

3.01.00 The motors will be installed in hot, humid and tropical atmosphere highly polluted at places with coal dust and/or fly ash.

3.02.00 Unless otherwise noted, electrical equipment/system design shall be based on the service conditions and auxiliary power supply given in the annexure to this specification.

3.03.00 For motor installed outdoor and exposed to direct sunrays, the effect of solar heat shall be considered in the determination of the design ambient temperature.

4.00.00 **TYPE AND RATING**

4.01.00 **A.C. Motors**

4.01.01 Motors shall be general purpose, constant speed, squirrel cage, three/single phase, induction type.

4.01.02 All motors shall be rated for continuous duty. They shall also be suitable for long period of inactivity.

4.01.03 LT motor & HT motor name-plate rating at 50°C shall have at least 15% margin and 10% margin respectively over the input power requirement of the driven equipment at rated duty point unless stated otherwise in driven equipment specification.

4.01.04 The motor characteristics shall match the requirements of the driven equipment so that adequate starting, accelerating, pull up, break down and full load torques are available for the intended service.

4.01.05 Motors efficiency class shall be **IE3** as per latest version of IEC-60034.

4.02.00 **D.C. Motors**

4.02.01 D.C. motor provided for emergency service shall be shunt/compound wound type.

4.02.02 Motor shall be sized for operation with fixed resistance starter for maximum reliability.

Starter panel complete with all accessories shall be included in the scope of supply.

5.00.00 **PERFORMANCE**

5.01.00 **Running Requirements**

5.01.01 Motor shall run continuously at rated output over the entire range of voltage and frequency variations as given in the annexure.

5.01.02 The motor shall be capable of operating satisfactorily at full load for 5 minutes without injurious heating with 75% rated voltage at motor terminals.

5.01.03 The motor shall be designed to withstand momentary overload of 60% of full load torque for 15 second without any damage.

5.02.00 **Starting Requirements**

Motor shall be designed for direct online starting at full voltage. Breakaway starting current as percentage of full load current for various motor rating shall not exceed the given below-

Motors up to 1500kW	-	600% subject to IS tolerance of plus 20%.
Motors above 1500kW	-	450% not subject to any positive tolerance.

5.02.01 The motor shall be capable of withstanding the stresses imposed if started at 110% rated voltage.

5.02.02 Motor shall start with rated load and accelerate to full speed with 80% rated voltage at motor terminals except mill motor. Mill motor shall start with rated load and accelerate to full speed at 85% of the rated voltage at the motor terminals.

5.02.03 a) Two hot starts in succession with motor initially at normal running temperature.

b) Pump motor subject to reverse rotation shall be designed to withstand the stresses encountered when starting with shaft rotating at 125% rated speed in reverse direction.

5.02.04 The motors shall be designed to withstand 120% of rated speed for 2 minutes without any mechanical damage.

5.03.00 **Stress During Bus Transfer**

5.03.01 The motor may be subjected to sudden application of 150% rated voltage during bus transfer, due to the phase difference between the incoming voltage and motor residual voltage.

5.03.02 The motor shall be designed to withstand any torsional and/or high current stresses, which may result, without experiencing any deterioration in the normal life and performance characteristics.

5.04.00 **Locked Rotor Withstand Time**

5.04.01 The locked rotor withstand time under hot condition at 110% rated voltage shall be more than motor starting time by at least 3 seconds for motors up to 20 seconds starting time and by 5 seconds for motor with more than 20 seconds starting time.

5.04.02 Starting time mentioned above is at minimum permissible voltage of 80% rated voltage.

5.04.03 Hot thermal withstand curve shall have a margin of at least 10% over the full load current of the motor to permit relay setting utilising motor rated capacity.

6.00.00 **SPECIFIC REQUIREMENTS**

6.01.00 **Enclosure**

6.01.01 All motor enclosures for outdoor, semi-outdoor & indoor application shall conform to the degree of protection IP-55 unless otherwise specified. Motor for outdoor or semi-outdoor service shall be of weather-proof construction with canopy.

6.01.02 For hazardous area approved type of increased safety enclosure shall be furnished.

6.02.00 **Cooling**

6.02.01 The motor shall be self ventilated type, either totally enclosed fan cooled IC 411(TEFC), totally enclosed tube ventilated IC 511(TETV) or closed air circuit air- cooled IC 611(CACA).

6.02.02 For large capacity motors not available with above type of cooling may be accepted with IC 81W or IC 91W, closed air circuit water cooled (CACW) subject to the approval of the owner.

6.03.00 **Winding and Insulation**

6.03.01 All insulated winding shall be of copper.

6.03.02 All motors shall have class F insulation but limited to class B temperature rise.

6.03.03 Windings shall be impregnated to make them non-hygroscopic and oil resistant.

6.04.00 **Tropical Protection**

6.04.01 All motors shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.

6.04.02 All fittings and hardwares shall be corrosion resistant.

6.05.00 **Bearings**

6.05.01 Motor shall be provided with antifriction bearings, unless sleeve bearings are required by the motor application. Bearings shall be rated for minimum service life of 40,000Hrs.

6.05.02 Vertical shaft motors shall be provided with thrust and guide bearings. Thrust bearing of tilting pad type is preferred.

6.05.03 Bearings shall be provided with seals to prevent leakage of lubricant or entrance of foreign matters like dirt, water etc. into the bearing area.

6.05.04 Sleeve bearings shall be split type, ring oiled, with permanently aligned, close running shaft sleeves.

6.05.05 Grease lubricated bearings shall be pre-lubricated and shall have provisions for in-service positive lubrication with drains to guard against over lubrication. LT motors 15kW and above shall be provided with external greasing arrangement.

6.05.06 Oiled bearing shall have an integral self cooled oil reservoir with oil ring inspection ports, oil sight glass with oil level marked for standstill and running conditions and oil fill and drain plugs.

6.05.07 Forced lubricated or water cooled bearing shall not be used without prior approval of Owner.

6.05.08 Lubricant shall not deteriorate under all service conditions. The lubricant shall be limited to normally available types with IOC equivalent.

6.05.09 Bearings shall be insulated as required to prevent shaft current and resultant bearing damage.

6.06.00 **Noise & Vibration**

6.06.01 All HT motors shall be provided with vibration pads for mounting of vibration detectors. Vibration monitoring devices shall be provided on DE and NDE side in x&y direction with remote DCS monitoring, alarm and tripping.

6.06.02 The maximum double amplitude vibrations for HT motors upto 1500 rpm shall be 25 microns and 15 microns upto 3000 rpm. For 415V motors, maximum double amplitude vibrations upto 1500 rpm shall be 40 microns and 15 microns upto 3000 rpm.

6.06.03 The noise level shall not exceed 85db (A) at 1.5 meters from the motor.

6.07.00 **Motor Terminal Box**

6.07.01 Motor terminal box shall be detachable type and located in accordance with Indian Standards clearing the motor base- plate/ foundation

6.07.02 Terminal box shall be capable of being turned 360 Deg. in steps of 180 Deg. for HT motors and 90 Deg. for LT motors unless otherwise approved.

6.07.03 The terminal box shall be split type with removable cover with access to connections and shall have the same degree of protection as motor.

6.07.04 The terminal box shall have sufficient space inside for termination/connection of XLPE insulated armoured aluminium cables.

6.07.05 Terminals shall be stud or lead wire type, substantially constructed and thoroughly insulated from the frame.

6.07.06 The terminals shall be clearly identified by phase markings, with corresponding direction of rotation marked on the non-driving end of the motor.

6.07.07 The terminal box shall be capable of withstanding maximum system fault current for a duration of 0.25 sec.

6.07.08 For 11000V and 3300V motor, the terminal box shall be phase-segregated type. The neutral leads shall be brought out in a separate terminal box (not necessarily phase segregated type) with shorting links for star connection.

6.07.09 Motor terminal box shall be furnished with suitable cable lugs and double compression brass glands to match with cable used.

6.07.10 The gland plate for single core cable shall be non-magnetic type.

6.07.11 Minimum clearances to be provided between phase to phase and phase to earth shall be as under-

Voltage Rating of Motor		Minimum Ph-Ph & Ph-Earth clearance
0.415 kV	:	25 mm
3.3 kV	:	65 mm
11.0 kV	:	140 mm

Note: In case it is not possible to maintain these clearances, the live parts shall be totally insulated from earth and other Phases. Adequate clearances shall be provided for cable connections.

6.08.00 **Grounding**

6.08.01 The frame of each motor shall be provided with two separate and distinct grounding pads complete with tapped hole, GI bolts and washer.

6.08.02 The grounding connection shall be suitable for accommodation of ground conductors as follows:

Rating			Conductor Size
Above	Up to		
-------	5.5 kW	:	8 SWG GI Wires.
5.5 kW	22 kW	:	25mm X 4mm GS Flat.
23 kW	55 kW	:	40mm X 6mm GS Flat.
56kW	174kW	:	50mm X 8mm GS Flat.
175kW	ABOVE	:	75mm X 10mm GS Flat.

6.08.03 The cable terminal box shall have a separate grounding pad.

6.09.00 **Minimum Cable Size for LT & HT Motors shall as be as follows-**

a) For 415V, 3-Ph, LT Motors-

Rating		:	Cable Size
Above	Up to		
-------	5.5 kW	:	1R X 3C X 6 Sq.mm
5.5 kW	11 kW	:	1R X 3C X 10 Sq.mm
11 kW	22 kW	:	1R X 3C X 35 Sq.mm
22 kW	37.5 kW	:	1R X 3C X 70 Sq.mm.
37.5kW	55 kW	:	1R X 3C X 150 Sq.mm
55 kW	75 kW	:	1R X 3C X 300 Sq.mm
75 kW	110kW	:	2R X 3C X 150 Sq.mm
110 kW	175kW	:	2R X 3C X 300 Sq.mm

b) For 3.3kV & 11kV, 3-Ph, HT Motors-

Rating		:	Cable Size
Above	Up to		

175 kW	1000 kW	:	1R X 3C X 240 Sq.mm
1000 kW	2000 kW	:	2R X 3C X 240 Sq.mm
2000 kW	4500 kW	:	2R X 3C X 300 Sq.mm
4501 kW	10,000 kW	:	9R X 1C X 1000 Sq.mm.

Note: During detail engineering if higher cable size is required same shall be provided.

6.10.00 **Rating Plate**

In addition to the minimum information required by IS, the following information shall be shown on motor rating plate :

a) Temperature rise in Deg.C under rated condition and method of measurement.

b) Degree of protection.

c) Bearing identification no. and recommended lubricant.

d) Location of insulated bearings.

7.00.00 **ACCESSORIES**

7.01.00 **General**

Accessories shall be furnished, as listed below, or if otherwise required by driven equipment specification or application.

7.02.00 **Space Heater**

7.02.01 Motor of rating 30 kW and above shall be provided with space heaters, suitably located for easy removal or replacement.

7.02.02 The space heater shall be rated 240 V, 1 Phase, 50Hz and sized to maintain the motor internal temperature above dew point when the motor is idle.

7.02.03 Minimum Cable Size for space heater shall be as listed-

i) For LT motors: 2.5 sq.mm, 2-Core copper cable complying with IS-1554(Part-1).

ii) For HT motors: 6 sq.mm, 2 Core aluminium cable complying with IS-1554(Part-1).

7.03.00 **Temperature Detectors**

7.03.01 All 11000V and 3300V motors shall be provided with twelve (12) nos. simplex type winding temperature detectors, four (4) nos. per phase.

7.03.02 11000V and 3300V motor bearing shall be provided with duplex type temperature detectors.

7.03.03 The temperature detector mentioned above shall be resistance type, 3 wire, platinum wound, 100 Ohms at 0°C.

7.03.04 Leads of all simplex type motor winding RTDS and motor bearing RTDS shall be wired up to respective switchgear metering & protection compartment. From which one set of RTDS will be connected to numerical protection relay and another set shall be kept free for DDCMIS connectivity.

7.03.05 0.5 sq.mm annealed tinned copper conductor complying with IS-1554(Part-1). shall be used for RTD/BTD wiring.

7.04.00 **Indicator/Switch**

7.04.01 Dial type local indicator with alarm contacts shall be provided for the following:

a) 11000 V and 3300V motor bearing temperature.

b) Hot and cold air temperature of the closed air circuit for CACA and CACW motor.

7.04.02 Flow switches shall be provided for monitoring cooling water flow of CACW motor and oil flow of forced lubrication bearing, if used. CACW motor shall be provided with water leakage detector with remote alarm and tripping.

7.04.03 Alarm switch contact rating shall be minimum 2.0 A at 220V D.C. and 10A at 240V A.C.

7.05.00 **Current Transformer for Differential Protection**

7.05.01 Motor 1000 kW and above shall be provided with three differential current transformers mounted over the neutral leads within the enclosure.

7.05.02 The arrangement shall be such as to permit easy access for C.T. testing and replacement. Current transformer characteristics shall match Owner's requirements to be intimated later.

7.06.00 **Accessory Terminal Box**

7.06.01 All accessory equipment such as space heater, temperature detector, current transformers etc., shall be wired to and terminated in terminal boxes, separate from and independent of motor (power) terminal box.

7.06.02 Accessory terminal box shall be complete with double compression brass glands and pressure type terminals to suit owner’s cable connections.

7.07.00 **Drain Plug**

Motor shall have drain plugs so located that they will drain the water, resulting from the condensation or other causes from all pockets of the motor casing.

7.08.00 **Lifting Provisions**

Motor weighing 25 Kg. or more shall be provided with eyebolt or other adequate provision of lifting.

7.09.00 **Dowel Pins**

The motor shall be designed to permit easy access for drilling holes through motor feet or mounting flange for installation of dowel pins after assembling the motor and driven equipment.

7.10.00 **Painting**

For paint shade finish, refer Section-X of Volume: II-A : Lead Specification.

8.00.00 **TESTS**

Routine and Type Tests are to be conducted in presence of customer's representative as per IS:325 and in addition,any special test called for in the driven equipment specification shall be performed and required copies of test certificates are to be furnished for approval. In addition, following tests shall have to be carried out on the motors in presence of OWNER's representative on 3.3kV/11kV motors.

a. Impulse test by 1.2 / 50 micro sec. On sample coil of Stator winding insulation as type test as per IEC-60034, part -15 test voltages as under :

Voltage rating of motor	Impulse Test Voltage
3.3 kV	18 kV peak
11 kV	49 kV peak

b. Tan delta, charging current and dielectric loss measurements on each phase of motor stator winding as routine test.

c. Polarization Index Test as per IS: 7816 as routine test

d. Test for suitability of IPW– 55(Weather proof) as per IS 4691 as type test. Type test certificate for first numeral shall be acceptable in lieu to test, provided the test motor is identical to motor being supplied. Second numeral test shall be carried out on one motor of each type and rating.

e. Fault Withstand Test for main terminal box as type test. Type test certificate shall be acceptable, if the test is conducted on exactly identical terminal box.

f. Test for noise level as routine test.

g. Test for vibration as routine test.

h. Tan delta measurement on coils.

i. Surge withstand test for inter turn insulation.

j. Test to diagnose rotor bar failure during manufacture.

k. Over speed test as routine test.

l. Temperature rise test.

Temperature rise under normal condition above ambient temperature shall be limited to-

Specified Design Ambient temperature	Thermometer Method	Resistance Method
50 deg.C	60 deg.C	70 deg.C
45 deg.C	65 deg.C	75 deg.C
40 deg.C	70 deg.C	80 deg.C

Tests indicated at (h), (i), (j) shall be carried out during manufacture of the coils and shall be furnished for verification.

9.00.00 **DRAWINGS, DATA & MANUALS**

9.01.00 Drawings, Data & Manuals shall be submitted in triplicate with the bid and in quantities and procedures as specified in General Conditions of Contract and/or elsewhere in the specification for approval and subsequent distribution after the issue of 'Letter of Intent'.

9.02.00 **To be Submitted with the bid**

a) List of the motors

b) Individual motor data sheet as per format of the proposal data sheets.

c) Scheme & write-up on forced lubrication system, if any

d) Type test report

9.03.00 **To be submitted for Owner / Purchaser's Approval and Distribution**

All relevant drawings and data pertaining to the equipment like GTP, GA drawing, foundation plan, QAP, etc. shall be submitted by the Bidder for approval of Owner/Owner's consultant. Also refer clause no. 1.19.02(u) of Section-I of Volume – V-A: Technical Specifications for Electrical Equipment & Accessories.

ANNEXURE-A

DESIGN DATA

1.0 AUXILIARY POWER SUPPLY

Supply		Description	Consumer
H.V. Supply		11000 V, 3Ø, 3W, 50 Hz, Non-effectively earthed Fault level 44 kA symm. for 1 sec.	Motors 1500 kW & above
M.V. Supply		3300 V, 3Ø, 3W, 50 Hz, Non-effectively earthed Fault level 40 kA symm. for 1 sec.	Motors 175 kW and Up to less than 1500 kW.
L.V. Supply	(i)	415V, 3Ø, 3W, 50 Hz effectively earthed Fault level 50 kA symm. for 1 sec.	Motors above 0.2kW and below 175kW.
	(ii)	240V AC/415V AC 240V, 1Ø, 2W, 50 Hz effectively earthed	Motors upto 0.2kW. Lighting, Space heating , A.C supply for Control & protective devices.
D.C. Supply		220V, 2W, unearthed Fault level 25* kA. for 1 sec.	D.C. alarm, control & protective devices

* Indicative only, the actual value will be decided by the Bidder, after substantiating the same by calculation.

Note-

- 415V or 3.3 kV may be adopted by the bidder for the drives in the range of 160-210 kW.
- 3.3 kV AC supply for CHP conveyor motors of rating above 160 kW is to be used.
- The voltage rating of the drives indicated above is for basic guideline. Minor variations can be accepted on case to case basis based on techno-economic considerations of the various sub-systems.
- Voltage rating for special purpose motors viz, VFD and screw compressors, shall be as per manufacturer's standard. All the motors ratings on Stacker/ reclaimer shall be 415V ac supply only.

2.0 RANGE OF VARIATION

A.C. Supply :

Voltage	:	± 10%
Frequency	:	+3% to -5%
Combined Volt + frequency	:	10% (absolute sum)

During starting of large motor, the voltage may drop to 80% of the rated voltage for a period of 60 seconds. All electrical equipment while running shall successfully ride over such period without affecting system performance.

D.C. Supply :

Voltage	:	187 to 242 Volt

VOLUME: V-A

SECTION-III

TECHNICAL SPECIFICATION
FOR
ELECTRIC MOTOR ACTUATORS

CONTENT

CLAUSE NO.	DESCRIPTION
1.00.00	SCOPE
2.00.00	STANDARDS
3.00.00	SERVICE CONDITIONS
4.00.00	RATING
5.00.00	PERFORMANCE
6.00.00	SPECIFIC REQUIREMENT
7.00.00	ACCESSORIES
8.00.00	TEST
9.00.00	DRAWINGS, DATA & MANUALS

ATTACHMENT

ANNEXURE-A	DESIGN DATA

VOLUME: V-A

SECTION-III

TECHNICAL SPECIFICATION FOR ELECTRIC MOTOR ACTUATORS

1.00.00 **SCOPE**

1.01.00 This Section covers the general requirements of Electric Motor Actuators for valves/dampers.

1.02.00 All electric motor actuators shall be furnished in accordance with this general specification and the accompanying driven equipment specification. All the electrical actuators shall be INTEGRAL type only.

2.00.00 **STANDARDS**

2.01.00 All electrical equipment shall conform to the latest applicable IS, ANSI and NEMA Standards, except when stated otherwise herein or in driven equipment specification.

2.02.00 Major standards, which shall be followed, are listed below. Other applicable Indian Standards for any component part even if not covered in the listed standards shall also be followed

i) IS-9334

ii) IS-325

3.00.00 **SERVICE CONDITIONS**

3.01.00 The actuator shall be suitable for operation in hot, humid and tropical atmosphere, highly polluted at places with coal dust and/or fly ash.

3.02.00 Unless otherwise noted, electrical equipment/system design shall be based on the service conditions and auxiliary power supply given in the general specification.

3.03.00 For actuator motor installed outdoor and exposed to direct sun rays, the effect of solar heat shall be considered in the determination of the design ambient temperature.

4.00.00 **RATING**

4.01.00 For isolating service, the actuator shall be rated for three successive open-close operation of the valve/damper or 15 minutes, whichever is longer.

4.02.00 For regulating service, the actuator shall be suitably time-rated for the duty cycle involved with necessary number of starts per hour, but in no case less than 150 starts per hour.

5.00.00 **PERFORMANCE**

The actuator shall meet the following performance requirements:

5.01.00 Open and close the valve completely and make leak-tight valve closure without jamming.

5.02.00 Attain full speed operation before valve load is encountered and imparts an unseating blow to start the valve in motion (hammer blow effect).

5.03.00 Operate the valve stem at standard stem speed and shall function against design differential pressure across the valve seat.

5.04.00 The motor reduction gearing shall be sufficient to lock the shaft when the motor is de-energised and prevent drift from torque switch spring pressure.

5.05.00 The entire mechanism shall withstand shock resulting from closing with improper setting of limit switches or from lodging of foreign matter under the valve seat.

6.00.00 **SPECIFIC REQUIREMENT**

6.01.00 **Construction**

6.01.01 The actuator shall essentially comprise the drive motor, torque/ limit switches, gear train, clutch, hand wheel, position indicator/ transmitter, in-built thermostat for over load protection, space heater and internal wiring.

6.01.02 The actuator enclosure shall be totally enclosed, dust tight, weather-proof suitable for outdoor use without necessity of any canopy. Degree of protection of enclosure for motor actuator shall be IP-65.

6.01.03 All electrical equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.

6.01.04 The actuator shall be designed for mounting in any position without any lubricant leakage or operating difficulty.

6.02.00 **Motor**

6.02.01 The drive motor shall be three phase, squirrel cage, induction machine with minimum class B insulation and IPW-55 enclosure, designed for high torque and reversing service. Canopy shall be provided for outdoor service.

6.02.02 The motor shall be designed for full voltage direct on-line start, with starting current limited to 6 times full-load current.

6.02.03 The motor shall be capable of starting at 85 percent of rated voltage and running at 80 percent of rated voltage at rated torque and 85 percent rated voltage at 33 percent excess rated torque for a period of 5 minutes each.

6.02.04 Motor leads shall be terminated in the limit switch compartment.

6.02.05 Motor actuators for valves/dampers shall be with integral starter with 3phase/3wire, 415V AC and operable from remote.

6.02.06 Earthing terminals shall be provided on either side of the motor.

6.03.00 **Limit Switches**

Each actuator shall be provided with following limit switches: -

6.03.01 2 torque limit switches, one for each direction of travel, self-locking, adjustable torque type.

6.03.02 4 end-of-travel limit switches, two for each direction of travel.

6.03.03 2 position limit switches, one for each direction of travel, each adjustable at any position from fully open to fully closed positions of the valve/damper.

6.03.04 Each limit switch shall have 2 NO + 2 NC potential free contacts. Contact rating shall be 5A at 240V A.C. or 0.5A at 220V D.C.

6.04.00 **Hand Wheel**

Each actuator shall be provided with a hand wheel for emergency manual operation. The hand wheel shall declutch automatically when the motor is energized.

6.05.00 **Position Indicator/Transmitter**

The actuator shall have:

6.05.01 One (1) built-in local position indicator for 0-100% travel.

6.05.02 One (1) position transmitter, 4-20 mA current signal as position feedback, for remote indicator.

6.06.00 **Space Heater**

A space heater shall be included in the limit switch compartment suitable for 240V, 1 phase, 50 Hz supply.

6.07.00 **Wiring**

All electrical devices shall be wired up to and terminated in a terminal box. All wiring shall be done with 1100V grade fire resistance PVC insulated stranded copper conductor of not less than 2.5 Sq.mm cross section. All wiring shall be identified at both ends with ferrules. All the electrical actuators shall have uniform wiring.

6.08.00 **Terminal Box**

The terminal box shall be weather proof, with removable front cover and cable glands for cable connection. The terminal shall be suitable for connection of 2.5 Sq.mm copper conductor.

7.00.00 **ACCESSORIES**

As required for the driven equipment, the actuator shall be furnished with starting equipment mounted on the actuator. This shall include:

7.01.00 One (1) triple pole MCCB

7.02.00 One (1) reversing starter with mechanically interlocked contactors, 3 thermal overload relays, 2 NO + 2 NC auxiliary contacts for each contactor.

7.03.00 One (1) remote-local selector switch.

7.04.00 CLOSE-STOP-OPEN oil tight push buttons with indication lights.

7.05.00 415/240 V control transformer with primary & secondary fuses.

8.00.00 **TEST**

The actuator and all components thereof shall be subject to tests as per relevant Standards. In addition, if any special test is called for in equipment specification, the same shall be performed.

9.00.00 **DRAWINGS, DATA & MANUALS**

9.01.00 Drawings, Data & Manuals shall be submitted in triplicate with the bid and in quantities and procedures as specified in General Conditions of Contract and/or elsewhere in the specification for approval and subsequent distribution after the issue of 'Letter of Intent'.

9.02.00 **To be submitted with Bid**

Data sheet for each type of actuator shall be furnished along with internal wiring diagram, suggested control schematic and torque limit switch contact development and manufacturer's catalogues. Drawings, Data & Manuals shall be submitted in triplicate with the bid and in quantities and procedures as specified in General Conditions of Contract and/or elsewhere in the specification for approval and subsequent distribution after the issue of 'Letter of Intent'.

9.03.00 **To be submitted for Owner / Purchaser’s Approval and Distribution**

All relevant drawings and data pertaining to the equipment like GTP, GA drawing, foundation plan, BOM, control & schematics, QAP, etc. shall be submitted by the Bidder for approval of Owner/Owner’s consultant. Also refer clause no. 1.19.02(u) of Section-I of Volume – V-A: Technical Specifications for Electrical Equipment & Accessories.

ANNEXURE-A

DESIGN DATA

1.0 AUXILIARY POWER SUPPLY

Supply		Description	Consumer
L.V. Supply	(i)	415V, 3Ø, 3W, 50 Hz Effectively earthed	Motors above 0.2kW upto less than 175kW.
		Fault level 50 kA symm. for 1 sec.	
	(ii)	240V AC/415V AC	Motors upto 0.2kW.
		240V, 1Ø, 2W, 50 Hz effectively earthed	Lighting, Space heating , A.C supply for Control & protective devices.
D.C. Supply		220V, 2W, unearthed	D.C. alarm, control & protective devices
		Fault level 25* kA. for 1 sec.	

* Indicative only, the actual value will be decided by the Bidder, after substantiating the same by calculation.

2.0 RANGE OF VARIATION

A.C. Supply :

Voltage	:	± 10%
Frequency	:	+3% to -5%.
Combined Volt + frequency	:	10% (absolute sum)

During starting of large motor, the voltage may drop to 80% of the rated voltage for a period of 60 seconds. All electrical equipment while running shall successfully ride over such period without affecting system performance.

D.C. Supply :

Voltage	:	187 to 242

GENERAL TECHNICAL REQUIREMENTS

FOR

LV MOTORS

1.0 INTENT OF SPECIFIATION

The specification covers the design, materials, constructional features, manufacture, inspection and testing at manufacturer's work, and packing of Low voltage (LV) squirrel cage induction motors along with all accessories for driving auxiliaries in thermal power station.

Motors having a voltage rating of below 1000V are referred to as low voltage (LV) motors.

2.0 CODES AND STANDARDS

Motors shall fully comply with latest edition, including all amendments and revision, of following codes and standards:

IS:325	Three phase Induction motors
IS : 900	Code of practice for installation and maintenance of induction motors
IS: 996	Single phase small AC and universal motors
IS: 4722	Rotating Electrical machines
IS: 4691	Degree of Protection provided by enclosures for rotating electrical machines
IS: 4728	Terminal marking and direction of rotation rotating electrical machines
IS: 1231	Dimensions of three phase foot mounted induction motors
IS: 8789	Values of performance characteristics for three phase induction motors
IS: 13555	Guide for selection and application of 3-phase A.C. induction motors for different types of driven equipment
IS: 2148	Flame proof enclosures for electrical appliance
IS: 5571	Guide for selection of electrical equipment for hazardous areas
IS: 12824	Type of duty and classes of rating assigned
IS: 12802	Temperature rise measurement for rotating electrical machnines
IS: 12065	Permissible limits of noise level for rotating electrical machines
IS: 12075	Mechanical vibration of rotating electrical machines

In case of imported motors, motors as per IEC-34 shall also be acceptable.

3.0 DESIGN REQUIREMENTS

3.1 Motors and accessories shall be designed to operate satisfactorily under conditions specified in data sheet-A and Project Information, including voltage & frequency variation of supply system as defined in Data sheet-A

3.2 Motors shall be continuously rated at the design ambient temperature specified in Data Sheet-A and other site conditions specified under Project Information
Motor ratings shall have at least a 15% margin over the continuous maximum demand of the driven equipment, under entire operating range including voltage & frequency variation specified above.

3.3 Starting Requirements

3.3.1 Motor characteristics such as speed, starting torque, break away torque and starting time shall be properly co-ordinated with the requirements of driven equipment. The accelerating torque at any speed with the minimum starting voltage shall be at least 10% higher than that of the driven equipment.

3.3.2 Motors shall be capable of starting and accelerating the load with direct on line starting without exceeding acceptable winding temperature.

The limiting value of voltage at rated frequency under which a motor will successfully start and accelerate to rated speed with load shall be taken to be a constant value as per Data Sheet - A during the starting period of motors.

3.3.3 The following frequency of starts shall apply

i) Two starts in succession with the motor being initially at a temperature not exceeding the rated load temperature.

ii) Three equally spread starts in an hour the motor being initially at a temperature not exceeding the rated load operating temperature. (not to be repeated in the second successive hour)

iii) Motors for coal conveyor and coal crusher application shall be suitable for three consecutive hot starts followed by one hour interval with maximum twenty starts per day and shall be suitable for mimimum 20,000 starts during the life time of the motor

3.4 **Running Requirements**

3.4.1 Motors shall run satisfactorily at a supply voltage of 75% of rated voltage for 5 minutes with full load without injurious heating to the motor.

3.4.2 Motor shall not stall due to voltage dip in the system causing momentary drop in voltage upto 70% of the rated voltage for duration of 2 secs.

3.5 **Stress During bus Transfer**

3.5.1 Motors shall withstand the voltage, heavy inrush transient current, mechanical and torque stress developed due to the application of 150% of the rated voltage for at least 1 sec. caused due to vector difference between the motor residual voltage and the incoming supply voltage during occasional auto bus transfer.

3.5.2 Motor and driven equipment shafts shall be adequately sized to satisfactorily withstand transient torque under above condition.

3.6 Maximum noise level measured at distance of 1.0 metres from the outline of motor shall not exceed the values specified in IS 12065.

3.7 The max. vibration velocity or double amplitude of motors vibration as measured at motor bearings shall be within the limits specified in IS: 12075.

4.0 **CONSTRUCTIONAL FEATURES**

4.1 Indoor motors shall conform to degree of protection IP: 54 as per IS: 4691. Outdoor or semi-indoor motors shall conform to degree of protection IP: 55 as per IS: 4691and shall be of weather-proof construction. Outdoor motors shall be installed under a suitable canopy

4.2 Motors upto 160KW shall have Totally Enclosed Fan Cooled (TEFC) enclosures, the method of cooling conforming to IC-0141 or IC-0151 of IS: 6362.

Motors rated above 160 KW shall be Closed Air Circuit Air (CACA) cooled

4.3 Motors shall be designed with cooling fans suitable for both directions of rotation.

4.4. Motors shall not be provided with any electric or pneumatic operated external fan for cooling the motors.

4.5 Frames shall be designed to avoid collection of moisture and all enclosures shall be provided with facility for drainage at the lowest point.

4.6 In case Class 'F' insulation is provided for LV motors, temperature rise shall be limited to the limits applicable to Class 'B' insulation.
In case of continuous operation at extreme voltage limits the temperature limits specified in table-1 of IS:325 shall not exceed by more than 10°C.

4.7 **Terminals and Terminal Boxes**

4.7.1 Terminals, terminal leads, terminal boxes, windings tails and associated equipment shall be suitable for connection to a supply system having a short circuit level, specified in the Data Sheet-A.

Unless otherwise stated in Data Sheet-A, motors of rating 110 kW and above will be controlled by circuit breaker and below 110 kW by switch fuse-contactor. The terminal box of motors shall be designed for the fault current mentioned in data sheet "A".

4.7.2 unless otherwise specified or approved, phase terminal boxes of horizontal motors shall be positioned on the left hand side of the motor when viewed from the non-driving end.

4.7.3 Connections shall be such that when the supply leads R, Y & B are connected to motor terminals A B & C or U, V & W respectively, motor shall rotate in an anticlockwise direction when viewed from the non-driving end. Where such motors require clockwise rotation, the supply leads R, Y, B will be connected to motor terminals A, C, B or U W & V respectively.

4.7.4 Permanently attached diagram and instruction plate made preferably of stainless steel shall be mounted inside terminal box cover giving the connection diagram for the desired direction of rotation and reverse rotation.

4.7.5 Motor terminals and terminal leads shall be fully insulated with no bar live parts. Adequate space shall be available inside the terminal box so that no difficulty is encountered for terminating the cable specified in Data Sheet-A.

4.7.6 Degree of protection for terminal boxes shall be IP 55 as per IS 4691.

4.7.7 Separate terminal boxes shall be provided for space heaters.. If this is not possible in case of LV motors, the space heater terminals shall be adequately segregated from the main terminals in the main terminal box. Detachable gland plates with double compression brass glands shall be provided in terminal boxes.

4.7.8. Phase terminal boxes shall be suitable for 360 degree of rotation in steps of 90 degree for LV motors.

4.7.9 Cable glands and cable lugs as per cable sizes specified in Data Sheet-A shall be included. Cable lugs shall be of tinned Copper, crimping type.

4.8 Two separate earthing terminals suitable for connecting G.I. or MS strip grounding conductor of size given in Data Sheet-A shall be provided on opposite sides of motor frame. Each terminal box shall have a grounding terminal.

4.9 **General**

4.9.1 Motors provided for similar drives shall be interchangeable.

4.9.2 Suitable foundation bolts are to be supplied alongwith the motors.

4.9.3 Motors shall be provided with eye bolts, or other means to facilitate safe lifting if the weight is 20Kgs. and above.

4.9.4 Necessary fitments and accessories shall be provided on motors in accordance with the latest Indian Electricity rules 1956.

4.9.5 All motors rated above 30 kW shall be provided with space heaters to maintain the motor internal air temperature above the dew point. Unless otherwise specified, space heaters shall be suitable for a supply of 240V AC, single phase, 50 Hz.

4.9.6 Name plate with all particulars as per IS: 325 shall be provided

4.9.7 Unless otherwise specified, the colour of finish shall be grey to Shade No. 631 and 632 as per IS:5 for motors installed indoor and outdoor respectively. The paint shall be epoxy based and shall be suitable for withstanding specified site conditions.

5.0 INSPECTION AND TESTING

5.1 All materials, components and equipments covered under this specification shall be procured, manufactured, as per the BHEL standard quality plan No. PED-506-00-Q-006/0 and PED-506-00-Q-007/2 enclosed with this specification and which shall be complied.

5.2 LV motors of type-tested design shall be provided. Valid type test reports not more than 5 year shall be furnished. In the absence of these, type tests shall have to be conducted by manufacturer without any commercial implication to purchaser.

5.3 All motors shall be subjected to routine tests as per IS: 325 and as per BHEL standard quality plan.

5.4 Motors shall also be subjected to additional tests, if any, as mentioned in Data Sheet A.

6.0 DRAWINGS TO BE SUBMITTED AFTER AWARD OF CONTRACT

a) OGA drawing showing the position of terminal boxes, earthing connections etc.
b) Arrangement drawing of terminal boxes.
c) Characteristic curves:
(*To be given for motor above 55 kW unless otherwise specified in Data Sheet*).

i) Current vs. time at rated voltage and minimum starting voltage.
ii) Speed vs. time at rated voltage and minimum starting voltage.
iii) Torque vs. speed at rated voltage and minimum voltage.
For the motors with solid coupling the above curves i), ii), iii) to be furnished for the motors coupled with driven equipment. In case motor is coupled with mechanical equipment by fluid coupling, the above curves shall be furnished with and without coupling.
iv) Thermal withstand curve under hot and cold conditions at rated voltage and max. permissible voltage.

		QUALITY PLAN	CUSTOMER :			PROJECT TITLE			SPECIFICATION : NUMBER :			
			BIDDER/ VENDOR :			QUALITY PLAN NUMBER PED-506-00-Q-006, REV-01			SPECIFICATION TITLE			
		SHEET 1 OF 2	SYSTEM			ITEM AC ELECT. MOTORS BELOW 55KW (LV)			SECTION			VOLUME III
SL. NO.	COMPONENT/OPERATION	CHARACTERISTICS CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY P	AGENCY W	AGENCY V	REMARKS
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**			**11**
1.0	ASSEMBLY	1.WORKMANSHIP	MA	VISUAL	100%	MANUF'S SPEC	MANUF'S SPEC	-DO-	2	-	-	
		2.DIMENSIONS	MA	-DO-	-DO-	MFG. DRG./ MFG. SPEC.	MFG. DRG./ MFG. SPEC.	-DO-	2	-	-	
		3.CORRECTNESS COMPLETENESS TERMINATIONS/ MARKING/COLOUR CODE	MA	VISUAL	100%	MFG.SPEC./ RELEVANT IS	MFG.SPEC. RELEVANT IS	-DO-	2	-	-	
2.0	PAINTING	1.SHADE	MA	VISUAL	SAMPLE	MANUFR'S SPEC/BHEL SPEC./RELEVANT STANDARD	BHEL SPEC. SAME AS COL.7	LOG BOOK	2	-	-	
3.0	TESTS	1.ROUTINE TEST INCLUDING SPECIAL TEST AS PER BHEL SPEC.	MA	-DO-	100%	IS-325/ BHEL SPEC./ DATA SHEET	SAME AS COL.7	TEST REPORT	2	1		NOTE -1 & NOTE-3
		2.OVERALL DIMENSIONS & ORIENTATION	MA	MEASUREMENT & VISUAL	100%	APPROVED DRG/DATA SHEET	APPROVED DRG/DATA SHEET & RELEVANT IS	INSPN. REPORT	2	1	-	NOTE -1 & NOTE-3
BHEL			**PARTICULARS**		**BIDDER/VENDOR**							
			NAME									
			SIGNATURE									

	QUALITY PLAN	CUSTOMER :		PROJECT TITLE			SPECIFICATION : NUMBER :					
		BIDDER/ VENDOR :		QUALITY PLAN NUMBER PED-506-00-Q-006, REV-01			SPECIFICATION : TITLE :					
	SHEET 2 OF 2	SYSTEM		ITEM AC ELECT. MOTORS BELOW 55KW (LV)			SECTION			VOLUME III		
SL. NO.	COMPONENT/OPERATION	CHARACTERISTICS CHECK	CAT.	TYPE/ METHOD OF CHECK	EXTENT OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORM	FORMAT OF RECORD	AGENCY P	W	V	REMARKS
1	2	3	4	5	6	7	8	9	10			11
		3.NAMEPLATE DETAILS	MA	VISUAL	100%	IS-325 & DATA SHEET	IS-325 & DATA SHEET	INSPN. REPORT	2	1	-	

NOTES:

1 ROUTINE TESTS ON 100% MOTORS SHALL BE DONE BY THE VENDOR. HOWEVER, BHEL SHALL WITNESS ROUTINE TESTS ON RANDOM SAMPLES. THE SAMPLING PLAN SHALL BE MUTUALLY AGREED UPON

2 WHERE EVER CUSTOMER IS INVOLVED IN INSPECTION, (1) SHALL MEAN BHEL AND CUSTOMERS BOTH TOGETHER.

3 FOR EXHAUST/VENTILATION FAN MOTORS OF RATING UPTO 1.5KW , ONLY ROUTINE TEST CERTIFICATES SHALL BE FURNISHED FOR SCRUTINY.

Legends for Inspection agency

1. BHEL/CUSTOMER
2. VENDOR (MOTOR MANUFACTURER)
3. SUB-VENDOR (RAW MATERIAL/COMPONENTS SUPPLIER)

P. PERFORM
W. WITNESS
V. VERIFY

BHEL	**PARTICULARS**	**BIDDER/VENDOR**	
	NAME		
	SIGNATURE		
	DATE		BIDDER'S/VENDORS COMPANY SEAL

ANNEXURE-I

SUB-VENDOR LIST

The list of approved make of the LT Motors are as mentioned below:

S.No.	LIST OF LT MOTORS
1.	BHARAT BIJLEE LTD.
2.	CROMPTON GREAVES
3.	ASEA BROWN BOVERI
4.	KIRLOSKAR ELECTRIC CO LTD.
5.	NGEF
6.	SIEMENS
7.	MARATHON
8.	GE-POWER
9.	RAJINDRA ELECT INDUSTRIES
10.	LAXMI HYDRAULICS PVT. LTD

However, the final list of makes for the LT Motors is subjected to BHEL/Customer approval, during contract stage, without any commercial implications.

SUB-SECTION - IIC

STANDARD TECHNICAL SPECIFICATION (C &I)

BHEL	**SPECIFICATION FOR LOCAL PANELS**	SPECIFICATION NO.:
		VOLUME
		SECTION
		REV. NO. 00 / DATE :
		SHEET 1 OF 5

1.0 SCOPE

This specification covers the Design, Manufacture, Inspection and Testing at the manufacturer's works, proper packing for transportation and delivery to site, supervision, erection, and commissioning at site of Local Panels required for control and monitoring of the Auxiliary Plant & Equipment.

2.0 CODES AND STANDARDS

2.1 All the equipments specified herein shall comply with the requirements of the latest issue of the relevant National and International standards.

2.2 As a minimum requirement, the following standards shall be complied with:

a) IS-6005 : 1998 : Code of practice for phosphating of iron and steel.
b) IS-5 : 2007 : Colors for ready mixed paints and enamels.
c) IS-1248:2003 : Direct Acting Indicating Analog Elec Measuring Instruments.
d) IS/IEC 60947:Part 1:2004 : Low Voltage switchgear & control gear: Part-I (General Rules)
e) IS-8828:1996 : Circuit breaker for household and similar installations.
f) IS-13947 (Part-I):1993 : Low Voltage switchgear & control gear : Part-I (General Rules)
g) ISA-18.1:1979 : Annunciator Sequences and Specification
h) NFPA-496:2003 : Purged & Pressurised Enclosure for Electrical Equipment in Hazardous Locations.

3.0 TECHNICAL REQUIREMENTS

3.1 Panel Construction

3.1.1 The local panels shall house the secondary instruments, annunciation system, Single loop controller, Control switches / push buttons, indicating lamps/LED cluster, relays, timers and other devices required for operation and monitoring of the equipment locally.

3.1.2 The panels shall be of free standing type either welded construction on angle iron (minimum section of 50 x 50 x 4 mm) structure or folded construction by sheet metal formation depending upon the equipments to be mounted on it. The panels shall be robustly built and stiffeners as necessary shall be provided.

3.1.3 The panel shall be suitably reinforced to ensure adequate support for all instruments mounted thereon. All welds on exposed panel surfaces shall be ground smooth.

3.1.4 The salient features of construction shall be:

Sheet material: Cold rolled sheet steel
Frame thickness: Not less than 3.0mm
Enclosure thickness: Not less than 2.5 mm for load bearing sections (Mounted with instruments)
1.6 mm for doors and Not less than 2.0 mm for others
Gland plate thickness: 3.0mm
Base channel: ISMC 100 with anti-vibration mounting & foundation bolts.

3.1.5 The panel shall be provided with doors with integral lockable handle. The door when locked shall be held at minimum three places. The door width shall not be more than 550mm.The doors shall be provided with suitable stiffeners to prevent buckling. The handle shall be on the right side of the door. The door shall be removable type with concealed hinges to facilitate maintenance work. Suitable pocket inside the door shall be provided for keeping the drawings / documents.

3.1.6 Suitable neoprene gasket shall be provided on all doors and removable covers. Suitable ventilation system along with louvers shall be provided at bottom and top of the doors covered with removable wire mesh.

3.1.7 The class of protection shall be in accordance with IP-55 unless otherwise specified in the data sheet – A (No. PES-145-54A-DS1-0).

3.1.8 All steel surfaces shall be cleaned by sand / pellet blasting, treated for pickling, degreasing and phosphating etc. by seven tank method. The panel shall have a high quality finish and appearance. The panel shall be painted with two coats of primer followed by two coats of epoxy / synthetic enamel based final paint of color shade and finish as given in data sheet-A (No. PES-145A-DS1-0). Minimum thickness of the paint shall be 85 microns for external paint and 70 microns for internal paint.

3.1.9 The cable glands of the required size and type as given in data sheet-A (No. PES-145A-DS1-0) shall be supplied alongwith the Panel.

3.1.10 All operable and indicating devices shall be mounted on the front of the panel while aux. Relays / timers MCBs etc. required for realization of control logics shall be mounted on a mounting plate inside the panel. Auxiliary relays and timers etc. shall be grouped according to the control function.
The devices shall be located in such a way so as to ensure easy access for operation / maintenance.

3.1.11 Single / dual control power supply feeders of voltage class as specified in data sheet-A (No. PES-145A-DS1-0) shall be provided by the purchaser. In case redundant power supply feeders are provided then auto changeover unit shall be mounted on the panel are in the panel supplier's scope. Where DC control power supply is specified an additional 240V, 50 Hz AC supply feeder for powering of space heater and lighting shall be provided by the purchaser. Suitable arrangement shall be provided inside the panel to receive and terminate the power supply feeder(s). For this purpose MCBs of suitable current rating shall be provided by the vendor. A supervisory relay along with a pilot lamp to indicate control supply 'ON' shall be provided on the panel. Any other power supply required for the operation of the devices mounted in the panel shall be arranged by the vendor.

3.1.12 The internal wiring shall be carried out with 1100 volt grade PVC insulated copper multi strand wire / flexible of 1.5mm2 size. AC & DC wires shall be kept separate from each other. Separate coloured wires to be used for AC and DC circuits. All wires shall be properly numbered and identified with ferrules as per the Control scheme / wiring diagram. Wires shall be routed and run through PVC troughs.

3.1.13 Terminal blocks shall be clip on type, 1100 volts grade. Separate terminal blocks shall be used for AC & DC circuits. The terminals shall be suitable for terminating 0.5 mm2 to 2.5mm2 external cables. The TB points in terminal block shall be cage clamp type / screw type. The terminal for ammeters shall be provided with removable links for shorting CTs. Each terminal strip shall be provided with identification strip. The panel shall have ten (20) percent spare terminal.

3.1.14 The interior of each panel shall be suitably illuminated through fluorescent lamps / tube lights with shrouded cover of minimum 15W operable on 240V 50 Hz AC power supply through panel door switch. A 15 Amp. 3-pin Power receptacle shall be provided.

3.1.15 Suitable space heaters operable on 240 Volts 50 Hz AC power system shall be provided at the panel bottom. These shall be designed to maintain the panel temperature five (5) deg. C above the ambient temperature during maintenance shutdown. Suitable isolating and control devices comprising of MCB, thermostat etc. shall be provided for the space heater.

3.1.16 The panel shall be provided with a copper earth bus of 50 x 6 mm size running throughout the width of the panel. It shall be terminated internally with 10 mm bolts at extreme ends for connection to; main station earth. The panel mounted equipments / devices shall be connected to earth bus through green coloured PVC insulated stranded copper conductor of 2.5 mm2 size.

3.1.17 Local Panel shall be provided with main name plate of 150 mm x 40 mm size having inscription of 20 mm height. The individual devices on the panels shall be as provided with separate name plate with inscription of 3 mm height. The instrument / devices shall be provided with stick on label plates inside the panel. The material of the main and individual labels shall be three (3) ply 3 mm thick Traffolyte Sheet / 2 mm Anodised Aluminium Plate. The inscription shall be with white letters on black background on traffolyte sheet. The labels shall be fixed by self tapping non-rusting screws.

3.1.18 Vendor shall furnish electric load and heat load list (in case panel is to be placed in ac environment) of each panel.

3.2 Hazardous Area Panel Requirement

3.2.1 The Local Panel located in hazardous area shall be pressurized as per NFPA-496 requirements to render it non-hazardous. Alarms shall be provided for local and remote annunciation when pressurisation falls below 2.5 mm of water column. Protection shall be of type Z of NFPA-496. It shall not be possible to switch ON the power of purged section unless it is purged as per the recommendation of NFPA-496. Vendor must provide a protective device on the panel to protect the panel from over pressurisation.

3.2.2 Vendor shall supply pressurisation kit consisting of valves, restriction orifices, dual filter regulation, pressure gauges, pressure switches, rotameter etc. Pressurisation kit shall be surface mounting on a metal board and located outside the local panel. Pressurisation kit shall further consist of solenoid valve flow switch, timer blow off safety device etc., so as to make purging fully automatic. However final start shall be manual. Panel protection against over pressure to be provided as per NFPA-496.

3.2.3 Pressurised local control panel pressurization kit assembly design shall provide minimum leakage flow through the Local Control Panel. Panel venting shall be as per NFPA-496.

3.2.4 All components in the local panel like indicating instruments, push buttons switches, lamps etc., which are required to be energized without panel pressurization or before completion of purge cycle shall be explosion proof as per NEMA-7 & suitable for area classification.

3.2.5 All push buttons etc. requiring frequent operation during machine running shall have good positive sealing. Weatherproof housing or cover to be provided wherever necessary. Vendor shall provide pressurisation bypass switch outside explosion proof enclosure of pressurized panel with lamp indication. This shall be used only during maintenance. All hinges, screws, other non-painted metallic parts shall be of stainless steel material.

3.2.6 Provision to switch off manually all types of power shall be provided in the panel. In addition, it shall also be possible to switch off power circuits / components which are powered from motor control centre or control room manually in case of pressurization failure. All such cables from MCC and main control room shall be terminated in explosion proof boxes (NEMA-7).

3.3 Control & Monitoring devices

3.3.1 Instruments like Indicators, recorders, single loop controllers etc. as applicable and specified elsewhere for the plant / equipment shall be supplied and mounted on the panel.

3.3.2 Alarm Annunciator System

It shall be solid state discrete facia type having a sequence of ISA-S18.1A or as specified, opaque facia windows of 70 mm x 50 mm size, having two (2) lamps per window, and hooter of 10W, and provision for repeat group alarm at remote. The annunciator shall be provided with ten (10) percent spare windows or minimum two (2) windows along with electronics.

3.3.3 Relays

The relays shall be electromagnetic type suitable for specified control supply. Its contact configuration and rating shall be suitable for the specified control function. However minimum contact rating shall be 5 Amp AC & 2 Amp DC as applicable. There shall be ten (10) percent spare contacts.

3.3.4 Timers

The timers shall be electronic type suitable for specified control supply. Its contact configuration and rating shall be suitable for the specified control function. However, minimum contact rating shall be 5 Amp AC & 2 Amp DC as applicable.

3.3.5 Control / Selector Switches

Switches shall be Rotary Cam type with minimum of 5 Amps AC & 2 Amp DC continuous current rating. Selector switches shall be stay put type while control switches shall be spring-return-to-neutral type.

Contact configuration and rating shall be as per the control function requirement. The switches shall be lockable type wherever specified. Each switch shall be provided with engraved plates indicating the switch position / functions.

3.3.6 Push Buttons / Indicating Lights

The push buttons shall be momentary action self-resetting type, however stop P.B. for unidirectional drives shall be provided with manual reset facility. Its contact configuration & rating shall be as required for the control function but minimum 2 NO + 2 NC of 5 Amp. AC rating. It shall have round coloured projecting tab and engraved escutcheon plate / inscription plate. Colour coding of push buttons shall be as under:

RED	Motor OFF / Valve CLOSE	YELLOW	Alarm acknowledge	Left Hand Side
GREEN	Motor ON / Valve OPEN	BLACK	Lamp test	Right Hand Side

Indicating lights shall be suitable for direct connections across specified power supplies. It shall be fitted with built in resistance to prevent circuit tripping on shorting of lamp filament. It shall be fitted with LED cluster type lamp replaceable from front.

GREEN	Motor OFF / Valve CLOSED condition	AMBER	Motor tripped	Left Hand Side
RED	Motor ON / Valve OPEN condition	WHITE	Normal / healthy	Right Hand Side

3.3.7 Ammeters

Ammeter shall be 96 x 96 mm size, 90 deg. deflection, 1.5% accuracy, 1 Amp. CT operated or with 4-20mA input and Flush mounting type as called for in the data sheet-A (No. PES-145-54A-DS1-0). Ammeters for motors shall have six (6) times folded scale at upper end to enable motor starting current indication

3.3.8 Miniature Circuit Breaker (MCB)

These shall be instantaneous magnetic trip type for short circuit in addition to current time inverse delayed thermal trip feature for over current protection. The housing of MCB shall be made of non-ignitable, high impact material. It shall have minimum short circuit rating of 9 KA for AC Voltages and 4 KA for DC Voltages.

3.3.9 Makes of various instruments / devices shall be as given below

1.	Alarm Annunciators	:	Procon / IIC
2.	Ammeters	:	AEP / IMP
3.	Control / Selector Switches	:	Alsthom / Kaycee / Siemens / L&T
4.	Push Buttons / Indicating Lamps	:	Siemens / L&T / Teknic / Alsthom
5.	Auxiliary Relays	:	Jyoti / Siemens / L&T / OEN
6.	Timers	:	L&T / Alsthom / Bhartiya Cutler Hammer
7.	MCBs	:	S&S Power Engg. / Indo Asian / MDS
8.	Terminal Blocks	:	Jyoti / Elmex

4.0 TESTING AND INSPECTION

4.1 The bidder shall adopt suitable quality assurance program to ensure that the equipments offered will meet the specification requirements in full.

4.2 BHEL's standard Quality Plan for LCP is enclosed with the specification. The bidder shall furnish his acceptance to BHEL's QP and submit the signed and stamped copy of QP along with the offer.

4.3 The vendor shall conduct the following tests as a minimum requirement:

4.3.1 Routine Tests

1. High Voltage (H.V.)
2. Insulation Resistance (I.R.)
3. Functional

4.3.2 Type Tests

1. Enclosure Class Test

5.0 SPARES AND CONSUMABLES

5.1 Commissioning Spares and consumables

The bidder shall supply all commissioning spares and consumables 'as required' during Start-up, as part of the main equipment supply.

5.2. Mandatory Spares

The bidder shall offer alongwith main offer, the Mandatory Spares as specified elsewhere in the specification. The Mandatory Spares offered shall be of the same make and type as the main equipment.

5.3. Recommended Spares

The bidder shall furnish a list of Recommended Spares indicating the normal service expectancy period and frequency of replacement; quantities recommended for 3 years operation alongwith unit rate against each item to enable BHEL/BHEL's Customer to place a separate order later, if required.

6.0 DRAWINGS AND DOCUMENTS

6.1 The bidder shall furnish the following documents in required number of copies along with the bid :

1. Data Sheet no. PES-145A-DS1-0
2. General Arrangement Drawing.
3. Catalogue and technical information for instruments and devices.
4. Quality Plan.

6.2 The vendor shall furnish the following documents in required number as agreed after the award of contract:

1. Data Shee No. PES-145A-DS2-0
2. GA Drawing indicating layout of instruments, construction details, foundation details, cable gland plate alongwith cable glands and all details mentioned in this specification.
3. Control Schematic Diagram along with grouping of different terminals for various functions.
4. Catalogue and technical information for instruments and devices with selected options clearly marked.
5. O&M Manuals.
6. "As Built" Drawing.
7. CDs.

7.0 MARKING AND PACKING

7.1 Panel with all instruments / devices mounted on it shall be suitably packed & protected for the entire period of despatch, storage and erection against impact, abrasion, corrossion, incidental damage due to vermin, sunlight, high temperature, rain moisture, humidity, dust, sea-water spray (where applicable) as well as rough handling and delays in Transit and storage in open.

8.0 APPLICABLE DATA SHEET FORMS

This document shall be read with one or more of the following data sheet forms :

- Data sheet A&B for Local Panels : Data sheet no. PES-145A-DS1-0
- Data sheet C for Local Panels : Data sheet no. PES-145A-DS2-0

FORM NO. PEM-6666-0

	DATA SHEET FOR LOCAL PANELS	SPECIFICATION NO.:
		VOLUME
		SECTION
		REV. NO. / DATE:
		SHEET 1 OF 1

TAG No. ……. Qty..... Data Sheet No.: **PES-145A-DS1-0**

Data Sheet A & B

			DATA SHEET-A FOR LOCAL PANEL (TO BE FILLED BY PURCHASER)	DATA SHEET-B (TO BE FILLED-UP BY BIDDER)
GENERAL	MANUFACTURER			
	CONSTRUCTION		☐ FOLDED ■ WELDED (CRCA) (As per requirement)	
	ENCLOSURE SHEET THICKNESS	FRONT	▌2.0 mm	
		OTHER	▌2.0 mm	
		DOOR	▌2.0 mm	
TECHNICAL	INPUT POWER SUPPLY		☐ 240V 50 Hz AC ☐ 220V DC ■ 415V 3 PHASE	
	NO. OF FEEDERS		☐ ONE ▌ TWO	
	CONTROL SUPPLY		☐ 110V AC ☐ 220V AC ☐ 220V DC ■ During detailed engg. (As per requirement)	
	ALARM ANNUNCIATOR WINDOW (EXCLUDING SPARES)		AS REQUIRED	
	PAINT TYPE		☐ EPOXY ENAMEL ■ EPOXY POWDER COATED	
	PANEL COLOUR (EXTERNAL)		■ Exterior- Opaline green shade 275 of IS: 5 or equivalent international code ■ Interior- Brilliant White (To be finalized during detailed engineering.)	
	FINISH		■ MATT ☐ GLOSSY ☐ SEMI GLOSSY	
	PANEL COLOUR (INTERNAL)		■ BRILLIANT WHITE ☐ CREAM ☐ OFF WHITE	
	FINISH		☐ MATT ☐ GLOSSY ■ SEMI GLOSSY	
	CLASS OF PROTECTION		■ IP-42 ☐ IP-65	
	CONTROL HARDWARE		■ RELAY BASED	
	FOUNDATION ARRANGEMENT		■ FOUNDATION BOLTS ☐ ANCHOR FASTENERS	
	WEIGHT OF PANEL (Kg.)		BIDDER TO SPECIFY	
	PANEL TYPE		☐ PRESSURISED ■ UNPRESSURISED As per Requirement	
	CABLE GLAND		☐ SINGLE COMPRESSION ■ DOUBLE COMPRESSION	
	AMMETER (TYPE OF INPUT)		☐ 1 Amp CT ☐ 4-20 mA As per Requirement	

	PREPARED BY	**CHECKED BY**	**APPROVED BY**	COMPANY SEAL
NAME				NAME
SIGNATURE				SIGNATURE
DATE				DATE

FORM NO. PEM-6666-0

	DATA SHEET FOR LOCAL PANELS	SPECIFICATION NO.:
		VOLUME
		SECTION
		REV. NO. / DATE:
		SHEET 1 OF 1

TAG No. ……. Qty..... Data Sheet No.: **PES-145A-DS1-0**

Data Sheet C

DATA SHEET-C FOR LOCAL PANEL
(TO BE FILLED BY CONTRACTOR AFTER AWARD OF CONTRACT)

GENERAL	MANUFACTURER		
	CONSTRUCTION		
	ENCLOSURE SHEET THICKNESS	FRONT	
		OTHER	
		DOOR	
TECHNICAL	INPUT POWER SUPPLY		
	NO. OF FEEDERS		
	CONTROL SUPPLY		
	ALARM ANNUNCIATOR WINDOW (EXCLUDING SPARES)		
	PAINT TYPE		
	PANEL COLOUR (EXTERNAL)		
	FINISH		
	PANEL COLOUR (INTERNAL)		
	FINISH		
	CLASS OF PROTECTION		
	CONTROL HARDWARE		
	FOUNDATION ARRANGEMENT		
	WEIGHT OF PANEL (Kg.)		
	PANEL TYPE		
	CABLE GLAND		
	AAMETER (TYPE OF INPUT)		

	PREPARED BY	**CHECKED BY**	**APPROVED BY**	COMPANY SEAL
NAME				NAME
SIGNATURE				SIGNATURE
DATE				DATE

	5x800 MW TSGENCO YADADRI TPS **CONTROL & INSTRUMENTATION** Technical specification for **NATURAL DRAFT COOLING TOWER**	SPEC NO.: **PE-TS-417-145-IXXX** VOLUME SECTION REV. NO. 00 | DATE : 20.07.2017 SHEET OF

QAP FOR
LOCAL CONTROL PANEL

PEM :: C&I

STANDARD QUALITY PLAN
FOR
LOCAL CONTROL PANEL

STD QUALITY PLAN NO.:	**PE-QP-999-145-I056**
VOLUME	IIB
SECTION	D
REV. NO.	01 DATE: 22-02-2008
SHEET	1 OF 7

Sl. No.	Component / operation	Characteristics Checked	* Category	Type/Method of Check	Extent of Check	Reference documents	Acceptance Norms	Format of Records	Agency $			Remarks
									P	W	V	
	INCOMING											
1.0	Sheet Steel (CRCA & HR)	1. Chemical Composition	MA	Chemical analysis	Sample	IS:1079 IS:513	IS:1079 IS:513	Test Certificate	3	---	2	
		2. Bend Test	CR	Mech. test	Sample	IS:1079 IS:513	IS:1079 IS:513	Log Book	2	---	---	
		3. Surface finish	MA	Visual	100%	Factory Standard / Sample	Factory Standard / Sample	Log Book	2	---	---	
		4. Waviness	MA	Visual	100%	Factory Standard	No Waviness	Log Book	2	---	---	
		5. Thickness	MA	Measurement	100%	BHEL Spec.	BHEL Spec.	Log Book	2	---	---	
		6. Mill marking	MA	Visual	100%	Factory Standard	Factory Standard	Log Book	2	---	1	
2.0	Flats / Angles / Channels	1. Dimensions	MA	Measurement	Sample	IS:2062	IS:2062	Log Book	2	---	---	
		2. Surface Defects	MA	Visual	100%	Factory Standard / Sample	Factory Standard / Sample	Log Book	2	---	---	
		3. Straightness	MA	Measurement	100%	Factory Std.	Factory Std.	Log Book	2	---	---	
		4. Mill marking	MA	Visual	100%	IS:2062	IS:2062	Log Book	2	---	1	
3.0	Cables / Wires	1. Visual / Surface defects	MA	Visual	100%	BHEL Spec. and IS:1554 or IS:694	BHEL Spec. and IS:1554 or IS:694	Log Book	2	---	---	
		2. IR and HV	MA	Electrical	100%	BHEL Spec. and IS:1554 or IS:694	BHEL Spec. and IS:1554 or IS:694	Log Book	2	---	---	

LEGEND:
* CR - Critical characteristics; MA - Major characteristics; MI - Minor characteristics
$ P - Agency Performing the Test.; W - Agency Witnessing the Test.; V - Agency Verifying the Test.
1 - BHEL; 2 - Vendor; 3 - Sub-vendor

PEM :: C&I

STANDARD QUALITY PLAN FOR LOCAL CONTROL PANEL

STD QUALITY PLAN NO.:	**PE-QP-999-145-I056**
VOLUME	IIB
SECTION	D
REV. NO.	01 DATE: 22-02-2008
SHEET	2 OF 7

Sl. No.	Component / operation	Characteristics Checked	* Category	Type/Method of Check	Extent of Check	Reference documents	Acceptance Norms	Format of Records	Agency $ P	Agency $ W	Agency $ V	Remarks
		3. Conductor a) Resistance b) Size c) Sheet colour	 MA MA MA	 Electrical Measurement Visual	 100% 100% 100%	BHEL Spec. and IS:1554 or IS:694	BHEL Spec. and IS:1554 or IS:694	Log Book	2	---	---	
		4. Type / Routine Test Certificates	MA	Verification	100%	BHEL Spec. and IS:1554 or IS:694	BHEL Spec. and IS:1554 or IS:694	Log Book	3	---	2	
4.0	Electrical Components like Annunciator Transformers Lamps Switches PBs Contactors Relays Timers Space Heaters Thermostat Indicating meters etc.	1. Verification at make and Type	CR	Visual	Sample	BHEL Spec. and BOM	BHEL Spec. and BOM	Log Book	2	---	---	
		2. Verification of Test Certificates	CR	Scrutiny of Type / Routine T.Cs.	100%	Relevant IS	Relevant IS	Log Book	2	---	---	
		3. Operation / Functional check	CR	Electrical	Sample+ 100%@	Relevant Indian Std & Catalogue	Relevant Indian Std & Catalogue	Log Book	2	---	---	+ for relay & contactors only
		4. I.R.	MA	Electrical	100%	Relevant Indian Std & Catalogue	Relevant Indian Std & Catalogue	Log Book	2	---	---	@ for all components except relays & contactors.
		5. H.V.	MA	Electrical	100%	Relevant Indian Std & Catalogue	Relevant Indian Std & Catalogue	Log Book	2	---	---	
		6. Calibration	MA	Electrical	100%	Relevant Indian Std & Catalogue	Relevant Indian Std & Catalogue	Log Book	2	---	1	
		7. Pick up / Drop off Voltage	MA	Electrical	100%	Relevant Indian Std & Catalogue	Relevant Indian Std & Catalogue	Log Book	2	---	---	

LEGEND: * CR - Critical characteristics; MA - Major characteristics; MI - Minor characteristics

$ P - Agency Performing the Test. W - Agency Witnessing the Test. V - Agency Verifying the Test.

1 - BHEL 2 - Vendor 3 - Sub-vendor

PEM :: C&I

STANDARD QUALITY PLAN FOR LOCAL CONTROL PANEL

STD QUALITY PLAN NO.:	**PE-QP-999-145-I056**
VOLUME	IIB
SECTION	D
REV. NO.	01 DATE: 22-02-2008
SHEET	3 OF 7

Sl. No.	Component / operation	Characteristics Checked	* Category	Type/Method of Check	Extent of Check	Reference documents	Acceptance Norms	Format of Records	Agency $			Remarks
									P	W	V	
5.0	Misc. Components like Gaskets, Terminal Blocks etc.	1. Verification of Type / Make	MA	Visual	Sample	BHEL Spec. & Mfrs. Catalogue	BHEL Spec. & Mfrs. Catalogue	Log Book	2	---	---	
		2. Surface defects	MA	Visual	Sample	BHEL Spec. & Mfrs. Catalogue	BHEL Spec. & Mfrs. Catalogue	Log Book	2	---	---	
		3. IR / HV on Terminal Blocks	MA	Electrical	Sample	BHEL Spec. & Mfrs. Catalogue	BHEL Spec. & Mfrs. Catalogue	Log Book	2	---	---	
	IN PROCESS											
6.0	Blanking / Bending / Forming	1. Dimensions	MI	Measurement	100%	Approved Mfr. drgs.	Approved Mfr. drgs.	Log Book	2	---	---	
		2. Surface defects after bending	MA	Visual	100%	Factory Standard	Factory Standard	Log Book	2	---	---	
7.0	Nibbling / Punching	1. Cutout Sizes	MI	Measurement	100%	Approved Mfr. drgs.	Approved Mfr. drgs.	Log Book	2	---	---	
		2. Deburring	MA	Visual	100%	Approved Mfr. drgs.	Approved Mfr. drgs.	Log Book	2	---	---	
	ASSEMBLY											
8.0	Frame Assembly & Sheet fixing	1. Dimensions	MA	Measurement	100%	Approved drg. / Mfr. Standards	Approved drg. / Mfr. Standards	Log Book	2	---	2	
		2. Alignment	MA	Measurement	100%	Approved drg. / Mfr. Standards	Approved drg. / Mfr. Standards	Log Book	2	---	2	
		3. Welding Quality	MA	Visual	100%	Approved drg. / Mfr. Standards	Approved drg. / Mfr. Standards	Log Book	2	---	2	
		4. Surface defects	MA	Visual	100%	Approved drg. / Mfr. Standards	Approved drg. / Mfr. Standards	Log Book	2	---	2	

LEGEND:
* CR - Critical characteristics
MA - Major characteristics
MI - Minor characteristics

$ P - Agency Performing the Test.
W - Agency Witnessing the Test.
V - Agency Verifying the Test.

1 - BHEL
2 - Vendor
3 - Sub-vendor

PEM :: C&I

STANDARD QUALITY PLAN FOR LOCAL CONTROL PANEL

STD QUALITY PLAN NO.:	**PE-QP-999-145-I056**
VOLUME	IIB
SECTION	D
REV. NO.	01 DATE: 22-02-2008
SHEET	4 OF 7

Sl. No.	Component / operation	Characteristics Checked	* Category	Type/Method of Check	Extent of Check	Reference documents	Acceptance Norms	Format of Records	Agency $			Remarks
									P	W	V	
9.0	Pre-treatment and Painting	1. Pretreatment Process	MA	Visual	100%	Factory Standard & IS: 6005	Factory Standard & IS: 6005	Log Book	2	---	1	
		2. Process parameters like bath temp. concentration etc.	MA	Measurement	Periodic	Factory Standard & IS: 6005	Factory Standard & IS: 6005	Log Book	2	---	1	
		3. Dipping / Removal Time	MA	Measurement	100%	Factory Standard & IS: 6005	Factory Standard & IS: 6005	Log Book	2	---	1	
		4. Surface quality after every dip	MA	Visual	100%	Factory Standard & IS: 6005	Factory Standard & IS: 6005	Log Book	2	---	1	
		5. Primer after phosphating	MA	Visual, Thickness	100%	Factory Standard & IS: 6005	Factory Standard & IS: 6005	Log Book	2	---	1	
		6. Putty Application & Rubbing after primer	MA	Visual	100%	Factory Standard & IS: 6005	Factory Standard & IS: 6005	Log Book	2	---	1	
		7. Paint first coat	MA	Visual, Thickness	100%	Factory Standard & IS: 6005	Factory Standard & IS: 6005	Log Book	2	---	1	
		8. Putty Application and Rubbing after first coat of paint	MA	Visual	100%	Factory Standard & IS: 6005	Factory Standard & IS: 6005	Log Book	2	---	1	
		9. Paint second coat	MA	Visual, Thickness, Scratch test Colour adhesion	100%	Factory Standard & IS: 6005	Factory Standard & IS: 6005	Log Book	2	---	1	

LEGEND: * CR - Critical characteristics; MA - Major characteristics; MI - Minor characteristics

$ P - Agency Performing the Test.; W - Agency Witnessing the Test.; V - Agency Verifying the Test.

1 - BHEL; 2 - Vendor; 3 - Sub-vendor

PEM :: C&I

STANDARD QUALITY PLAN FOR LOCAL CONTROL PANEL

STD QUALITY PLAN NO.:	**PE-QP-999-145-I056**
VOLUME	IIB
SECTION	D
REV. NO.	01 DATE: 22-02-2008
SHEET	5 OF 7

Sl. No.	Component / operation	Characteristics Checked	* Category	Type/Method of Check	Extent of Check	Reference documents	Acceptance Norms	Format of Records	Agency $			Remarks
									P	W	V	
10.	Panel Wiring	1. Wiring Layout	MA	Visual	100%	Approved drgs. & Specs.	Approved drgs. & Specs.	Log Book	2	---	---	
		2. Wiring Termination (Crimped Lugs)	MA	Visual	100%	Approved drgs. & Specs.	Approved drgs. & Specs.	Log Book	2	---	---	
		3. Ferrule numbers	MA	Visual	100%	Approved drgs. & Specs.	Approved drgs. & Specs.	Log Book	2	---	---	
		4. Colour of wiring	MA	Visual	100%	Approved drgs. & Specs.	Approved drgs. & Specs.	Log Book	2	---	1	
		5. Size of Conductor	MA	Measurement	100%	Approved drgs. & Specs.	Approved drgs. & Specs.	Log Book	2	---	1	
11.	Component Mounting	1. Correct components	MA	Visual	100%	Approved drgs., Specs. & BOM	Approved drgs., Specs. & BOM	Log Book	2	---	---	
		2. Fixing	MA	Visual	100%	Approved drgs., Specs. & BOM	Approved drgs., Specs. & BOM	Log Book	2	---	---	
	FINAL											
12.	Final Inspection	1. Workmanship	MA	Visual	100%	Factory Standard	Factory Standard	Inspection Report	2	1	1	At Random by BHEL, based on 100 % internal test reports by Mfr.
		2. Component layout (neatness, accessibility & safety) Mounting / Proper fixing of all components	MA	Visual	100%	BHEL approved drg. / Spec.	BHEL approved drg. / Spec.	Inspection Report	2	1	1	
		3. Components identification Marking / Name plates	MA	Visual	100%	BHEL approved drg. / Spec.	BHEL approved drg. / Spec.	Inspection Report	2	1	1	

LEGEND:
* CR - Critical characteristics; MA - Major characteristics; MI - Minor characteristics
$ P - Agency Performing the Test. W - Agency Witnessing the Test. V - Agency Verifying the Test.
1 - BHEL; 2 - Vendor; 3 - Sub-vendor

PEM :: C&I

STANDARD QUALITY PLAN FOR LOCAL CONTROL PANEL

STD QUALITY PLAN NO.:	**PE-QP-999-145-I056**
VOLUME	IIB
SECTION	D
REV. NO.	01 DATE: 22-02-2008
SHEET	6 OF 7

Sl. No.	Component / operation	Characteristics Checked	* Category	Type/Method of Check	Extent of Check	Reference documents	Acceptance Norms	Format of Records	Agency $			Remarks
									P	W	V	
		5. Dimensions	MA	Measurement	100%	BHEL approved drg. / Spec., BOM	BHEL approved drg. / Spec., BOM	Inspection Report	2	1	1	At Random by BHEL, based on 100 % internal test reports by Mfr.
		6. Door functioning	MA	Functional	100%	BHEL approved drg. / Spec.	BHEL approved drg. / Spec.	Inspection Report	2	1	1	
		7. Paint Shade	CR	Visual	100%	BHEL approved drg. / Spec.	BHEL approved drg. / Spec.	Inspection Report	2	1	1	
		8. Paint Thickness	CR	Measurement	100%	BHEL approved drg. / Spec.	BHEL approved drg. / Spec.	Inspection Report	2	1	1	
		9. Workmanship of Gaskets	MA	Visual	100%	Factory Standard	Factory Standard	Inspection Report	2	1	1	
		10. Wiring Layout	MA	Visual	100%	BHEL approved drg.	BHEL approved drg.	Inspection Report	2	1	1	
		11. Wire Termination	MA	Pulling manually	Sample	-----	Firm termination	Inspection Report	2	1	1	
		12. Continuity	MA	Electrical	100%	-----	Continuity OK	Inspection Report	2	1	1	

LEGEND:
* CR - Critical characteristics; MA - Major characteristics; MI - Minor characteristics
$ P - Agency Performing the Test.; W - Agency Witnessing the Test.; V - Agency Verifying the Test.
1 - BHEL; 2 - Vendor; 3 - Sub-vendor

KKS NO. PHILOSOPHY

KKS NUMBERING PHILOSOPHY

For identifying (tagging) an instrument / equipment in Power plant KKS numbering scheme is used. The purpose is to assign a unique number to every equipment in the power plant. For C&I equipment unique number are to be provided up to the signal level so that a unique number Input / Output exist in DCS for every signal.

Normally KKS number is a 10 digit alpha-numeric code and is typically split into the following:

X	X	X	A	A	Y	Y	B	B	B

First three digits indicate the Sub-System. The Code for the major system are given as per **Annexure-**1.

Fourth and Fifth digits are the **Numerical Keys at System Code Level** and used to distinguish between main systems having same Alpha Codes.

Sixth and Seventh digits are the **Equipment** / **Apparatus** / **Measuring Circuit Code**. The code of various Equipment / Apparatus / Measuring Circuit is shown in **Annexure-2**

Eight, Nine and tenth digits are the **Numerical Keys at Equipment** / **Apparatus** / **Measuring Circuit Code** and used to distinguish between various instruments in the same sub-group. Numerical keys at System / Equipment / Apparatus / Measuring Circuit is shown in **Annexure-3**.

ANNEXURE-1

List of System / Sub-System Codes used in Power Plant:

1) Mill Reject Handling System: EUA

ANNEXURE-2

Standard Equipment Codes:

AA	Valves including drives, also hand operated
AB	Seclusions, Lock, Gates, Doors
AC	Heat Exchanger
AE	Turning, Driving, Lifting equipment
AF	Continuous conveyors, Feeders
AG	Generator Units
AH	Heating and Cooling Units
AK	Pressing and Packaging equipment
AM	Mixer, Stirrer
AN	Blower, Air Pumps / Fans, Compressor Units
AP	Pump Units
AT	Purification, Drying, Filter
AV	Combustion Equipment e.g. grates

Standard Apparatus Codes:

BB	Vessels and Tank
BF	Foundation
BG	Boiler Heating Surfaces
BN	Injector, Ejector
BP	Flow and throughput limitation equipment (Orifice)
BQ	Holders, Carrying Equipment, Support
BR	Piping, Ducts, Chutes, Compensator
BS	Sound Absorber
BU	Insulations, Sheatings

Standard Measuring Circuits Codes:

CD	Density
CE	Electrical Quantities
CF	Flow, throughput
CG	Distance, Length, Position
CK	Time
CL	Level

SECTION III

DOCUMENTS TO BE SUBMITTED BY BIDDER

1.	Guaranteed Cold water temperature at design capacity & parameters with the working cells	33 Deg. C

Authorized Signatory

Company seal

COMPLIANCE CERTIFICATE

The bidder shall confirm compliance with following by signing/ stamping this compliance certificate and furnish same with the offer.

a) The scope of supply, technical details, construction features, design parameters etc. shall be as per technical specification & there are no exclusions with regard to same.

b) There are no other deviations w.r.t. specification other than those furnished in the 'Schedule of Deviations'. Any other deviation, stated or implied, taken elsewhere in the offer stands withdrawn unless specifically brought out in the 'Schedule of Deviations'

c) We will submit QP in the event of order based on the guidelines given in the specification & QP enclosed therein. QP will be subject to BHEL/ CUSTOMER approval & customer hold points for inspection/ testing shall be marked in the QP at the contract stage. Inspection/ testing shall be witnessed as per same apart from review of various test certificates/ Inspection records etc.

d) All drawings/ data-sheets/ calculations etc. submitted along with the offer shall be considered for reference only, same shall be subject to BHEL/ CUSTOMER approval in the event of order.

e) The offered materials shall be either equivalent or superior to those specified in the specification.

For components where materials are not specified, same shall be suitable for intended duty, all materials shall be subject to approval in the event of order.

f) We will supply commissioning spares shall be supplied on 'As Required Basis' & prices for same included in the base price itself. Prices for special tools & tackles, if any, shall also be included in the base price.

g) All sub vendors shall be subject to BHEL/ CUSTOMER approval in the event of order.

h) The Performance guarantees shall stand valid till at least eighteen (18) months after full load commissioning of CT or as per commercial terms and conditions, whichever is later.

i) Specifically confirm compliance with Cl. Nos. 11.0 and their sub clauses of Sec. II of Technical Specification specification.

j) We will carry out hydrostatic testing of piping shall be carried out as specified i.e. at 1.5 times the design pressure.

Bidder's Authorized Signatory

Company Seal.

1. Guaranteed Cold water temperature at design capacity & parameters of approved Design of NDCT. ..... Deg. C

Authorized Signatory

Company seal

FORM NO PEM 6036-1

	TITLE *** SCHEDULE OF DEVIATIONS** ( ) From Conditions of Contract (Volume – 1) ( ) From General Technical Conditions (Volume – II A) ( ) From Technical Specifications (Volume –II B)	SPECIFICATION NO VOL III SHEET…….. OF……

We the undersigned hereby certify that the above mentioned are the only deviations.

PARTICULARS OF BIDDER / AUTHORISED REPRESENTATIVE				
NAME	DESIGNATION	SIGNATURE	DATE	COMPANY SEAL

5X800MW TSGENCO YADADRI TPS (UNIT 1 TO 5)

TECHNICAL SPECIFICATION
FOR
NATURAL DRAFT COOLING TOWERS
(TOTAL 2 BOOKS)

BOOK 2 OF 2

Specification No. : PE-TS-417-165-N002

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA – 201301

COOLING TOWER TECHNICAL SPECIFICATION COMPRISE 2 BOOKS:

CONTENTS

SECTION TITLE

BOOK – 1 of 2 – Mechanical Specifications

I Specific Technical Requirements

IA Specific Technical Requirements (Mechanical)
IB Specific Technical Requirements (Elec.)
IC Specific Technical Requirements (C&I)

II Standard Technical Specifications

IIA Standard Technical Specifications (Mechanical)
IIB Standard Technical Specifications (Elec.)
IIC Standard Technical Specifications (C&I.)

III Documents to be submitted by Bidder

IIIA Guarantee Schedule (To be submitted along with the Bid by all Bidders)
IIIB Compliance Certificate (To be submitted along with the Bid by all Bidders)

BOOK – 2 of 2 – Civil Specification

Part-I
Part-II

TELANGANA STATE POWER GENERATION CORPORATION LIMITED [TSGENCO]

YADADRI THERMAL POWER STATION
[5 x 800 MW]

NALGONDA, TELANGANA, INDIA

SPECIFICATION NO. PE-TS-417-600-C004

TECHNICAL SPECIFICATION FOR NATURAL DRAFT COOLING TOWER

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

PART - I

VOLUME: VII-D

TECHNICAL SPECIFICATION
FOR
NATURAL DRAFT COOLING TOWER (NDCT)

CONTENTS

CLAUSE NO.	DESCRIPTION	PAGE NO.
8.00.00	CIVIL AND ALLIED WORKS	VII-D : 15
9.00.00	CIVIL DESIGN BASIS	VII-D : 15
10.00.00	DELETED	
11.00.00	TEST AND INSPECTION	VII-D : 40
12.00.00	DELETED	
13.00.00	DELETED	
14.00.0	DELETED	

8.00.0 **CIVIL AND ALLIED WORKS**

8.01.0 The civil design and construction of the cooling tower shall be in accordance with the following technical specifications and the Data Specification Sheets enclosed with this specification –

a) Earthwork in Excavation and Backfilling.

b) Cement Concrete (Plain and Reinforced).

c) Masonry and Allied work.

d) Finish to Masonry and Concrete.

e) Metal doors, windows, ventilators, louvers etc.

f) Roof water proofing, insulation and allied work.

g) Painting, white washing, polishing etc.

h) Sheet work in roof and siding.

8.02.0 The technical specifications are of general nature. Only those portions of the specifications which relate to the various works required to be done as per the technical requirements as specified in the tender document need to be considered.

8.03.0 The Cooling Tower shell, ring beams, diagonal columns at base supporting the ring beam below shell, cold water basin, fill support frame work, hot water distribution duct, cold water channel, louver etc. shall be cast-in-situ RCC construction.

9.00.00 **CIVIL DESIGN BASIS**

9.01.00 Loading

The following loads shall be considered for the design of cooling towers:

a) Dead loads

b) Wind loads

c) Earthquake forces

d) Loads due to temperature and shrinkage effects. Temperature effects due to solar radiation shall also be considered.

e) Construction load

f) Foundation settlement etc.

g) Any other load likely to come on cooling tower.

9.01.1 **Dead Load**

For assessing the self-weight of the structure, the specific weight of the concrete shall be taken as 2500 kg/m^3. All other dead loads shall be assessed in accordance with relevant codal provision. Dead load shall include the self-weight of structure, weight of fill material, weight due to plugging/chocking of fills, weight of falling water, weight of hot water pipe, weight of water in hot water channel and distribution system including the self-weight of channel and distribution system, weight of drift eliminators etc.

Secondary stresses, if any, due to permanent fixtures on the shell shall also be considered. In addition, live load on the supporting structure due to maintenance activities related to fills /ducts/distribution system shall be considered.

9.01.2 **Wind Load**

The wind pressure on the tower shall be assessed on theoretical basis as well as with the help of Model tests in a wind tunnel of turbulent boundary layer.

All the theoretical methods outlined hereunder for estimating wind load on cooling tower shell shall be valid only if the towers spaced at clear distance of greater than 0.5 times the base diameter at the finished graded ground level. The theoretical method outlined herein forms the basis only for assessing lowest limit of wind forces and shell structure interaction.

For conducting model tests, bidders should survey the whole terrain and make their own assessment of likely critical wind forces & wind structure interaction. It would be the responsibility of the contractor to collect necessary meteorological data duly vetted from the recognized govt. agencies/institutions. After collection of necessary meteorological data, most critical wind speed, wind pressure distribution and other necessary parameter shall be determined by the bidder and get the same vetted by the above agency/appropriate agency(s). Then with the help of physical model tests in a

Wind tunnel, offering appropriate aerodynamic similitude, the contractor shall obtain the most critical forces, stresses etc. with cooling tower at various levels and locations. Such model test shall also include all adjacent topographical features, buildings, and other structures which are likely to influence the wind load pattern on the tower significantly. The model test shall be carried out in a well reputed institute/testing laboratory after obtaining prior approval from the Owner. The testing agency selected by the contractor shall have requisite experience and should have successfully carried out tests in the past for at least one cooling tower of similar capacity. The model tests shall be duly witnessed and approved by the Owner/consultant. The model test results shall be made available before final approval of the design.

The complete cooling tower shall be designed for all possible wind directions and on the basis of worst load conditions as obtained from Model test and theoretical methods. Under the theoretical method, the circumferential net wind pressure distribution and wind pressure coefficient (p1) for the tower shell (without meridional ribs) shall be obtained from the “Criteria for structural design of Reinforced concrete Nature Draft Cooling Towers IS: 11504-1985.

The above circumferential wind pressure coefficient (p1) shall be increased by multiplying it by 1.43 to account for turbulence in the incident wind and load intensification due to turbulence induced by the adjacent cooling tower or the other structures of significant dimensions. Therefore, the actual design circumferential net wind pressure coefficient (p) shall be computed as p=1.43(p1), where (p1) is the wind pressure coefficient as per IS: 11504-1985.Enhancement factor 1.43 is considered to take the interference effect of adjacent structures of significant dimensions into account.10% increment shall be considered for imperfection in construction as per IS: 11504.This factor shall be increased further by 10% during foundation design in absence of model test results. If the model is for C/L of shell, wind load shall be appropriately augmented to cater to the increase in diameter of the shell (O.D).

This design net pressure coefficient (p) and the distribution along the circumference of tower shall be used at all heights of the tower. The above design net pressure coefficient (p) shall include the effect of internal suction.

In order to compute the quasi- static design wind pressure at a given height along the circumference of the tower, the net design pressure coefficient (p) shall be multiplied by the wind pressure acting at that height [P(z)]. For details, reference shall be made to “Criteria for Wind Resistant Design of Structures and Equipments” and as given below.

The wind pressure at a given height [P(z)] shall be computed as per the stipulations of IS: 875 (Part 3)-1987. For computing the design wind pressure at a given height the basic wind speed (Vb) shall be taken as Vb=44m/sec at 10.0 meters height above mean ground level. For computing design wind

speed (Vz) at a height z, the risk co-efficient K1=1.08 shall be considered. For coefficient K2, Terrain category 2 and class 'C' as per table 2 of IS: 875 (Part-3) – 1987 (Latest) shall be considered. Coefficient K3 shall be determined by taking into account nearby plant site and other features of the station & topography. The wind direction for design purposes shall be the one which would induce the worst load conditions. However, coefficient K3 shall not be less than one under any circumstances. The wind pressure at a given height shall be computed theoretically in accordance to the IS Codal position given as under:

$Pz = 0.6\ Vz^2\ N/m^2$

The bidder shall also compute the wind pressure (pz) along the wind direction by Gust Factor (GF) or Gust effective factor method (GEF). Method for estimating the wind load on the tower and other elements, shall be based on IS: 875 (Part-3)-1987. While calculating the gust factor, the term 'b' shall be taken as the diameter of the throat in Fig. 10 of IS: 875 (Part-3)-1987.

Design of the tower shall satisfy quasi-static method & GEF method. Dynamic effects on the tower due to wind action shall also be investigated to ascertain the wind induced oscillation such as ovalling and excitation along and across the wind direction. Bidder shall carry out detailed analysis for the tower and consider the worst combination of static & dynamic effects.

In case the bidder proposes to adopt aerodynamic rough surface such as provision of meridional ribs in the cooling tower shell, the pressure coefficients as given in the VGB-BTR KUHLTUMRE GERMAN SPECIFICATIONS (latest) (structural design of cooling towers) shall be permitted. The provisions of BTR may be adopted for choosing the value of circumferential wind pressure coefficient (p1) only. The wind pressure coefficient (p1), as obtained from BTR after accounting for internal suction shall be multiplied by a factor of 1.43 to arrive at the net design pressure coefficient (p). The bidder shall furnish authorized English Translation of VGB-BTR KUHLTURME GERMAN SPECIFICATIONS (latest) for the review of the Owner. All other stipulations as specified in these specifications shall be met with.

Entire analysis and designs adopted shall be fully supported with authenticated literatures/documents along with relevant references where the same has been successfully implemented.

9.01.3 **Earthquake Forces**

The seismic analysis shall be carried out in accordance with IS: 1893 (all latest parts) by modal analysis for the hyperbolic cooling towers or any other method as approved by the Owner.Seismic zone to be considered as Zone III. The earthquake analysis of the shell and its support columns including the foundations shall be carried out by response spectrum method. For the fill supporting structures (RCC frames) response spectrum method is permitted. The modulus of elasticity for concrete shall be obtained from IS: 456-2000 Clause 6.2.3.1 with an Age Factor of 1.0. All the analysis shall be carried out as per the theory of elasticity.

Entire analysis and designs adopted shall be fully supported with authenticated literatures/documents along with relevant reference where the same has been successfully implemented.

9.01.4 **Loads due to temperature effects**

Stresses due to temperature effects:

The cooling tower shell shall be designed for stress due to axi-symmetric temperature distribution corresponding to external ambient temperature variation from 15.9^{o}C to 44.3^{0}C. However, thedetailed analysis of actual thermal gradient by considering temperatures inside the tower and external ambient temperatures shall be carried out furnishing detailed references and justification for the same.

The shell shall also be checked for thermal stresses arising due to partial operation of the tower in case the operational philosophy so demands. The analysis for the stresses resulting from non-axi-symmetric temperature loading shall be carried out. In such non-symmetric temperature loading, the calculation shall be based upon the operating specification. Besides, the shell shall also be designed for one sided solar radiation effect. Nevertheless an effective temperature difference of at least 25^{0} C across the shell thickness constant over the height and follow a sine functions along half the circumference shall be considered.

Entire analysis and designs adopted shall be fully supported with authenticated literatures / documents along with relevant references where the same has been successfully implemented.

9.01.5 **Construction Loadings**

The method of construction and the type of formwork to be used shall be decided by the bidder in advance and should be enclosed in the bids submitted. Construction loadings that may occur during execution of work shall be considered in the design of the cooling tower structure. Factors

Causing temporary loading may include the following depending upon the method of construction.

a) Barrowing of concrete

b) Scaffolding and formwork

c) Loads produced by anchoring devices of climbing scaffolds.

d) Hoist fixings

e) Storage of materials on scaffolding

f) Temporary access

g) Tower crane fixings

h) Works temporarily omitted for access purposes.

Any other load such as foundation settlement, etc.

All loads likely to act on cooling tower but not specified herein shall also be considered for the design of cooling tower structures.

In case different degrees of subsoil stiffness exist, effect of the same shall be taken into account. In such a case, for computing settlements, load distributing capacity of the shell may be considered. Differential settlement between adjacent sections of foundation shall be considered under most unfavorable load combination.

9.01.6 **Load Combinations**

Following minimum load combinations shall be considered for the design of cooling towers structures.

a) DL + WL + SL

b) DL + Se L

c) DL + TL

d) DL + WL + TL + SL

e) DL + Se L + TL + SL

f) 1.0 DL + 1.5 WL

g) 0.9 DL +1.5 WL

h) 0.9 DL-1.5WL

Where,

DL = Dead Load
WL = Wind Load
SL = Settlement Load
Se L = Seismic Load
TL = Thermal Load

In addition to above, construction loads shall be duly accounted for. Under TL various types of thermal loads, as described above, shall be considered separately. Besides above load combination, other load combinations as per relevant IS codes shall also be followed.

9.01.7 **Permissible Stresses**

For load combination (a) to (e) working stress method shall be done without considering 33% increase in permissible stresses in concrete and reinforcement.

For the load case (f) to (h) the shell of cooling towers shall be checked by limit state method as per IS: 456. The stress in the reinforcement steel shall not exceed 87% of the specific characteristic strength of reinforcement steel and the compressive stress in the concrete shall not exceed 45% of the specified 28 days cube strength of the concrete as per IS: 456.

In the design of the cooling tower shell, column, pile caps, pedestals, ring beams etc. no increase in the strength with the age of the concrete shall be permitted.

Permissible stress for steel structures shall be as per IS: 800 based on working stresses.

9.02.0 **Tower Design Consideration**

9.02.1 **General**

- The complete cooling tower, including the shell, columns, ring beam and foundation, shall be structurally analyzed using a proven finite element modeling technique or an approved alternative method including validation of software used for analysis. For elastic analysis, concrete may be assumed to be un-cracked, homogenous and isotropic. The design geometric profile, thickness variation and support conditions of shell shall be considered in the structural analysis.

- Analysis based on a recognized bending theory of the elastic shells shall be adopted for the design of the tower and supporting structures.

  Regardless of analysis method adopted, the equilibrium checks of internal forces and external loads shall be performed.

- Geometric imperfections, if exceed the permissible limit, then the analysis of shell shall take into account of such imperfections and resubmitted for Owner's approval.

- Boundary conditions shall be realistic and based on actual configuration. The magnitude of the calculated displacements should be within limits of the applied theory.

- A detailed dynamic analysis shall be carried out for complete tower for seismic forces by response spectrum method. Cooling tower shall also be designed for cross wind oscillations (wind induced vibration) if the fundamental natural frequency of the tower is less than or equal to 1 Hz. Frequency calculation for free vibration analysis shall also be furnished by bidder during detailed engineering.

9.02.2 **Size and Shape**

- The base diameter, air intake opening height, tower height and throat diameter shall be determined by thermal design consideration by the contractor and submitted to Owner for approval.

- As the range of possible hyperbolic shell shapes is infinite, the same shall generally conform to the following major proportions, which have been extensively adopted in cooling tower constructions.

  H/D = 1.2 to 1.55

  Where H is the total tower height above basin sill

  level Hb/H = 0.75 to 0.85

  Hb is the vertical distance from the throat to basin sill level and 'D' is the base diameter at basin sill level.

- However, other proven profiles may be permitted subject to approval from the Owner. Bidders shall submit along with the offer complete details of the profile, in case the profile is not within the limits stated above, and the names of the sites where such shell profiles have been successfully constructed. Notwithstanding what is stated above, the Owner reserves the right to accept / reject the shell profile.

9.02.3 **Tower Shell Boundary Conditions**

A. **Shell Analysis and Design**

The following boundary conditions shall be assumed for the design of cooling tower shell:

a) At Upper Edge

The top edge of the shell shall be gradually thickened to form a ring beam to guard against possible instability of the top of the shell due to high velocity wind gusts. Top edge shall be considered as a free edge in the analysis.

b) At Lower Edge

The lower edge of the shell shall be thickened to form a lower ring beam. The thickness transition from shell to lower ring beam shall be smooth and shall be considered as an integral part of the shell. The lower boundary of the shell shall be considered as elastically supported by discrete columns.

The influence of both support structure flexibility and foundation settlement shall be considered in the analysis and design of cooling tower shell. The shell analysis should include following information at 10^{O} plan angle and of not more than 0.05 of the shell height.

i) Meridional and circumferential direct stress resultants and the tangential shear stress resultants.

ii) Meridional and circumferential bending moments.

iii) Displacements normal to the shell mid-surface.

B. **Buckling of Tower Shells**

- Critical dynamic pressure (wind pressure) at buckling shall be calculated from BS: 4485 Part-4:1996.

- Buckling of Cooling Tower shell be checked as per Finite Element Analysis using software such as NISA 2, Ansys etc. The factor of safety for snap through buckling shall be more than 5. This requires nonlinear analysis including simulation of opening in the model. Alternatively, bifurcation buckling factor can be calculated using linear eigen value analysis with modulus of elasticity E=0.8Ec, to account for cracked section, with factor of safety more than 7.

- Besides above, a buckling analysis with wind forces should be made using the theoretical tower geometry and boundary conditions, including the influence of dead weight, by the method of buckling stress state (BSS) approach in accordance with the provisions of VGB/BS 4485.

- The buckling safety factor shall be at least 5.0 for load combinations of dead load + wind load.

- When imperfections in the shell geometry are larger than specified tolerances, the analysis should be rechecked to account for such imperfections and ensure that the desired buckling capacity remains.

C. **Opening in Shells**

- Opening through the shells should be avoided as far as possible. They should be of smallest required dimensions and shall be shaped such that stress concentration is minimized at the boundary of the opening. Should thickening of the edges be necessary, it shall be smoothly tempered back to the shell thickness.

- Openings shall be provided with additional edge reinforcement of a minimum cross sectional area at each edge equal to 75% of the reinforcement intercepted by the openings in the direction parallel to the edges. In addition diagonal reinforcement shall be provided at each corner as close as possible. The total cross-sectional area in cm^2 of this reinforcement shall be 0.5d, at each corner where'd' is the shell thickness in cm.

- No horizontal thrust due to the inlet piping shall be transmitted to the shell.

D. **Minimum Thickness of Shell**

The thickness of the shell shall ~~not~~ be minimum 300 mm or more as per design.

E. **Minimum Reinforcement in Shell Spacing and Placement**

- The reinforcement used shall be cold worked steel high strength deformed bars of grade Fe 415/500 conforming to IS: 1786 – latest. All reinforcement steel shall be corrosion resistant steel/HCRM. The minimum reinforcement to be provided shall be as follows:

- Top one third portion of shell: 0.4% of concrete cross-sectional area along circumferential direction and 0.35% of concrete cross sectional area along meridional direction.

- Remaining two-third portion: 0.35% of concrete cross-sectional area in both meridional and circumferential directions.
- Minimum bar diameter shall be 10 mm in transverse direction and 12 mm in meridional direction.
- Spacing of reinforcing bars should not exceed 200 mm in circumferential direction and 250 mm in meridional direction.
- The two layers of reinforcing meshes shall be adequately joined by S-hook over the total shell surface. At least two S-hooks in each square metre area of shell surface shall be provided. The hooks shall be of minimum 8 mm diameter bars.
- The concrete cover shall be 50 mm minimum. However, the clear cover shall not be less than 1.5 times diameter of bars. The relevant provisions of IS: 2210 – Criteria for the design of reinforced concrete shell structures and folded plates and IS: 2204 – Code of Practice for construction of reinforced concrete shell roof shall also be deemed to be applicable. All other design criteria for the cooling tower shell which are not specified above shall be in accordance with BS: 4485 Part 4 and BTR.

F. **Provision of meridional ribs in Cooling Tower Shell**

Meridional ribs in the cooling tower shell may be provided subject to the following conditions:

a) Minimum thickness of shell excluding ribs shall not be less than 300 mm.

b) Coefficients for pressure distribution around the cooling tower circumference including suction may be taken as per VGB-BTR KUCHLTURMEN SPECIFICATIONS (latest). All other factors including load intensification factors shall be as specified elsewhere in these specifications.

c) Shell buckling and strength shall be checked as per clause-9.02.03 B above without considering the effect of ribs.

d) All other stipulations as specified in these specifications shall be met with.

e) Bidder shall furnish an authorized English translation of the VGB-BTR KUCHLTURMEN GERMAN SPECIFICATIONS (Latest) during detailed engineering stage.

9.02.4 **Raker Columns**

Inclination of the column shall closely match the meridional slope at the shell so that the load transfer to foundation takes place through predominantly axial force in columns. Raker columns shall be designed for the most critical forces transferred to an individual raker column from superstructure considering various load combinations as specified in this document.

For selecting effective length of the raker columns, following restraints shall be considered:

a) In case columns restrained at both the ends, the effective length shall be 0.8 and 0.6 times the length of the column radially and tangentially respectively.

b) In case columns are restrained at one end only, the effective length of columns shall be 0.9 and 0.7 times the length of columns radially and tangentially respectively.

c) The columns shall be designed based on working stress method except for the forces from DL + 1.5 WL which shall be designed as per limit state of strength method of IS: 456.

d) The minimum size of raker column section shall be 1200 mm diameter or more as per design

e) The size of pedestals shall be such that it will have minimum 200 mm clear projection from the raker column.

9.02.5 **Crack Width Control**

Under working stress method the maximum crack width of tower shell, lintels, raker columns, cold water basin and fill support structure shall be controlled up to 0.1 mm on basis of formulas as per IS:456-2000 and relevant British codes.

Fill support structures and Drift Eliminators shall be designed as per the load combinations specified in this document. Appropriate Live Loads and imposed loads shall also be considered in addition. The design shall confirm to limit state method as per IS: 456. For fill support structure, the design shall be done considering the weight of fills, falling water, plugging/scaling load and the live load due to the maintenance activities.

9.02.6 **Pre-stressed Concrete Members**

Design, construction and workmanship of pre-stressed concrete, members shall be in accordance with IS: 1343 (Latest revision). Steel wire for pre-stressing shall conform to IS: 1785 (Part 1) (latest edition) or IS: 6003 (latest edition). Crack width control shall be limited to 0.1 mm.

Particular attention shall be paid to achieve an effective bond of the wires in pre-tensioned concrete units. For this purpose, indented wire shall be used. Wires shall be corrosive resistant. Concrete and grout used shall be sulphate resistant.

The bidder shall furnish a write-up for the method to be used for pre-stressed concrete structures.

9.02.7 **Liquid Retaining Structures**

a) The cold water basin including sludge pits, cold water channels, shall be designed as per IS: 456 (latest) with crack width control of 0.1 mm for outer face of the wall and inside face of the wall shall be designed as per IS 3370.

The structures shall be designed for the following conditions:

i) Water filled inside up to maximum level and no earth outside.

ii) Earth pressure with surcharge load of 2.5 t/m^2, as applicable, and with/without ground water table at 1.0m below finished ground level outside and no water inside.

b) The basin and associated structures shall be checked against uplift for basin empty condition. Stability shall be checked during construction stage as well as maintenance stage. The factor of safety shall be as per IS: 3370.

c) Loads during construction, erection and maintenance stage shall also be considered.

d) Temperature fluctuations from operation shall be obtained from the design data. Hot water temperature inside and cold air temperature outside shall be considered.

e) Basin floor slab shall be designed to rest on piles or raft/mat foundation including fill-pack support structures. The stiffness of the subsoil shall be taken into account. The founding level of the raft/mat shall be either on virgin ground level or shall be placed at higher level only after scooping out filled up soil up to virgin ground and then filling

Back with well compacted sand (80% of relative density) up to the founding level of the raft/mat. The bidder shall ascertain the safe bearing capacity of the stratum at the founding level and may adopt the same subject to Owner's approval.

f) Minimum thickness of basin slab shall be 300 mm with minimum reinforcement 0.35% of gross sectional area in both the directions. Reinforcement shall be placed in two layers, top and bottom surface. The effect of provision of flap valves/pressure release valves shall not be considered in the design of CW basin. In the space underneath the basin floor slab a layer of at least 100 mm thick PCC of mix 1:3:6 shall be provided.

g) All reinforcements used shall be corrosion resistant steel/HCRM.

h) The basin floor shall be cast in alternate bays in chequered pattern with sides not exceeding 4.5 meter

i) No pressure relieve valve to be used at basin floor.

9.02.8 **Water Distribution System**

The structural design of the water distribution system shall consider the worst combination of following loads:

a) Self-weight, other imposed loads and live load.

b) Hydraulic pressures during normal operations including pressure surges.

c) Hydraulic pressure due to mal-operation of the tower or supply pumps.

- The water distribution system shall be provided with adequate pressure surge relief facilities to prevent pressure loading in excess of values used in the design. If such facilities are not provided, a further increase in loading shall be considered in the design. For the structural design the pressure level to be considered shall not be less than 1.5 times the design pressure.

- The design of water distribution system and its supports shall be capable of accommodating all thermal stresses and movements due to changes in inlet water temperature and ambient temperature.

- The possibility of vibrations being imposed on the distribution system shall be investigated in the design. Seismic loading on the water distribution system shall also be taken into account.

- The design shall be carried out based on uncracked section as per IS: 3370 under normal operating conditions. Strength check for worst loading including malfunctioning shall be carried out with stress limitations as per IS: 3370. The construction shall be completely water tight without the use of fillets, sealing compounds etc. The method of construction shall be such so as to avoid excessive rise in temperature of concrete due to release of heat of hydration.

- Hot water distribution basin/trough/channel at top shall be covered by removable precast concrete slab to prevent direct exposure from sunlight. Corners of pre-cast concrete slabs shall be protected by angles. Lifting lugs shall also be provided for handling of concrete slabs.

- Basin channel wall shall be designed for a minimum surcharge load of 25 KN/Sqm. Paving shall be provided all round cold water basin.

9.02.9 **Platforms, Walkways, Stairways, Staircases, Internal Grillage etc.**

These shall be designed as per working stress method IS: 456-2000 and IS: 800. The crack width in all RCC structures shall be limited to 0.1 mm. A minimum live load of 500 kq/sqm shall be considered for the design of all platforms, walkways, staircases etc. in addition to their own weight.

Platforms shall be minimum 1.2 M wide and walkways shall have 1.5 M wide.

9.02.10 **Steel Structures**

All structural steel members shall conform to IS: 2062 (GR-A). These structures shall be designed, fabricated and erected as per IS: 800 and other relevant Indian Standard codes for structural steel work. All steel structures shall be coated with anticorrosive system.

9.02.11 **Slide Gates and Screens**

Slide Gates and Screens, as per IS: 5620 conforming to IS: 2062 Gr. A, shall be designed for worst combination of operating and maintenance condition. All steel components shall be coated with anti-corrosive paint system. However, all guides of slide gates and screens shall be of stainless steel of Grade AISI 316L.

9.03.0 **Foundations**

Data specification sheet and Soil Report (By EPC Contractor) shall be referred to for selecting allowable bearing pressure to be considered in designing the foundation and in selecting depth of foundation. Cooling tower foundation is to be designed as strip foundation considering appropriate modulus of subgrade reaction. However, the bidder has to select suitable type of foundation compatible with the soil strata and calculated settlement of structure and foundation system. The bidder shall have to furnish conceptual design indicating type of foundation, general arrangement drawing for super structure, basin, pipe supports, pits, founding level etc. including settlement criteria complete with a design basis report with the offer.

The design of the cooling tower foundation structures shall be based on IS: 456 as per working stress method for worst load combination as per clause 9.01.06 In case of load combination DL + 1.5 WL, the limit state method as per IS: 456 shall be adopted.

Foundation shall be checked for safety against overturning, sliding and uplift. The minimum factors of safety for overturning, sliding and hydrostatic uplift shall be 1.5, 1.5 and 1.25 respectively.

While checking stability of the structures, neglect favourably acting loads from water fill, soil cover beyond the edge of the foundation. Ground water table shall be considered at 1.0m below Plant Finished Grade Level for design of foundations and all underground structures.

Minimum grade of concrete shall be M25 for foundation resting over 100mm thick PCC (1:3:6) layer. Clear cover shall not be less than 50mm.

Pile foundation if adopted shall be designed in accordance with IS: 2911(Part-I / Sec-I, II and III).

Generally net tension should be avoided in the foundations/piles for the shell support foundation unless specifically permitted by the Owner.

While accounting for over burden of the soil for checking the foundation against up-lift, dead weight of the soil directly above the pile cap or ring raft, as the case may be, shall only be considered, neglecting the weight of soil in the cone of up-lift above the foundation.

The foundation structures will be subjected to following loading and extreme load combination case shall be considered for design.

1. Most critical forces transferred from superstructure for the various load combinations.

2. Uplift forces

3. Loading due to foundation settlement

4. Concentrated local loading from column nodes

5. Thermally induced local loading where supply culverts pass through the foundation structures without structural isolation.

6. Surcharge of 2.5 t/sq.m.

CW basin surcharge load shall also be considered in addition to the other relevant loads for the design.

9.04.0 **Fill Support Structures and Other Structures**

The self-weight of the pack support structures shall be based on the weight of the packing including weight of standing, running and dripping water, other operation and plugging/chocking (debris/scaling) loads, etc. in accordance with manufacturer's data. In addition, a live load of 100 kg/m2 shall also be considered for the design of supporting structures.

For other structures like walkways, platforms, etc. a live load of 500 kg/sq.m shall be considered. Hand railings shall be designed for horizontal load of 60 kg/m2.

Wind deflector walls and any other structural elements shall be designed for a horizontal wind load of 80 kq/sqm or as per manufacturer's recommendations, whichever is higher. Thermal loading shall be as per manufacturer's recommendations. Earthquake loading shall be considered based on criteria given for cooling tower. Response spectrum analysis shall be considered.

Design of RCC members shall be based on IS: 456:2000 with limiting crack width of 0.1 mm.

The cold water basin slab/raft shall form the common foundation for the pack support structures. The foundation shall be designed for the most critical forces transferred from CW basin & fill supporting structures including loads introduced by constructional equipment and crane deployed for fill supporting structure or shell erection.

9.05.0 **Requirements for Concrete and Reinforcement**

All concrete work for the cooling tower shall comply with the requirements given in technical specification for Cement Concrete (Plain & reinforced)

Ordinary Portland cement Grade 53 complying with IS: 12269 shall be used in concrete works for all structures and foundations. For PCC, paving and plinth protection works, OPC Grade 43 shall be used.

Fine and coarse aggregate to be used in cement shall comply with IS-383.

Structural concrete shall be of design mix complying with the relevant provisions of IS codes or any International Code of Practice as approved by the Owner.

Durability of the concrete shall conform to severe exposure category as per Table 3 of IS: 456 except noted specifically otherwise.

Plain mild steel reinforcing bar shall conform to IS: 432 grade I quality and high yield strength deform bars (TMT) shall conform to IS: 1786 (Fe-500).

All reinforcements used in RCC structure shall be corrosion resistant. Column reinforcing bars shall be carefully anchored in the shell and foundation. The anchoring length shall not be less than 80 times the diameter of the bars.

All foundations structures shall be provided on all sides with a minimum reinforcement of 0.12% of gross cross-sectional area distributed over top and bottom faces.

The minimum grade of concrete of structural components of cooling towers shall be as follows in accordance with IS: 456.

a)	Shell and Raker Columns	: M-30 grade
b)	Pre-cast pre-stressed elements	: M-30 grade
c)	All other RCC concrete	: M-30 grade
d)	PCC encasement concrete except piles	: M-25 grade
e)	Piles (with OPC/PPC/PFC)	: M-30 grade
f)	Tower foundation	: M-30 grade
g)	Mud mat/lean concrete PCC	: M-10 grade

Coarse and fine aggregates shall be specially selected to ensure that they are not susceptible to alkali/chloride attack or prone to disintegration at high temperatures. In particular limestone aggregates shall never be used. The maximum size of coarse aggregate shall not be larger than 1/8th narrowest dimension between reinforcement bars not more than 20 mm.

Washing and screening of coarse and fine aggregates to remove fines, dirt or other deleterious materials shall be carried out by approved means as directed by the Engineer-in-charge.

The water cement ratio by weight shall be 0.45 maximum including free moisture in the aggregates, and slump should be suitably decided to provide good quality concrete work.

9.06.0 **Admixtures**

Admixtures may be permitted to be used in accordance with relevant IS codes to modify the rate of hardening or setting, to improve workability or as an aid to control concrete quality and protection to reinforcement bars against corrosion. The Owner reserves the right to direct the contractor to conduct laboratory tests or use test data, or other satisfactory reference before granting approval. The cost of all tests conducted shall be borne by the contractor. The admixture shall be used in strict accordance with the manufacturer's directions and/or as directed by the Owner. No extra payment will be made to the contractor on account of using admixtures.

Particular attention must be given to concrete placement because of the thin wall section and the presence of reinforcing steel. Consolidation of concrete shall be by vibration. Removal of air and water at the form surface shall be by vibration and rodding. Particular attention shall be paid to accurately shape the corners at all openings.

Point of discharge of the concrete in to the forms be 1500 mm max. above the concrete surface. Concrete shall be deposited in approximately level layers not greater than 400 mm deep unless permitted otherwise.

Concrete in the cooling tower shell in each lift shall be so laid that the no. of vertical or inclined construction joints are minimized to the extent possible. Horizontal construction joints shall be maintained at uniform spacing throughout the height of the cooling tower as per the directions of the Owner.

Special attention shall be paid to proper curing of vertical faces of the cooling tower shell so that these do not remain dry. All thin walled structural members shall be protected by means of curing agents. It is recommended to use a curing agent for the cooling tower shell providing additional protection like a single transparent cooling with a material based on vinyl mixed polymer. Inside face of the shell should be protected by a second pigmented coating of the same base material. Any other method of curing, if permitted by the Owner may be used.

Sampling and testing of concrete shall be carried out as stated in Technical Specification elsewhere and as per relevant Indian Standard Codes. However, following minimum tests shall be carried out, irrespective of whatever stated otherwise:

Test of compressive strength

Columns – 1 Set of 3 cubes per column

Shell-2 sets of 3 cubes per climbing section

9.07.0 **Cover to Reinforcement**

Unless indicated otherwise the clear concrete cover for reinforcement shall be as per IS Codes.

The correct cover shall be maintained by cement mortar spacers/cubes or other approved means, reinforcement for footing/pile caps, grade beam, and slabs on sub-grade shall be supported on pre-cast concrete cover block as approved by Engineer-in-charge. The use of pebbles or stones as cover blocks shall not be permitted.

The 28 days crushing strength of cement mortar cubes/pre-cast concrete coverblocks shall be at least one grade higher the specified strength of the concrete in which the cubes / blocks are embedded.

The minimum clear distance between reinforcing bars shall be in accordance with IS: 456 (latest edition) or as specified elsewhere in this specification.

All lapping of reinforcement bars in the cooling tower shell shall be by lapping as per relevant codal provisions. Prior approval of the Owner shall be taken for deciding the method of lapping the reinforcement bars in the shell.

9.08.0 **Checking of shell geometry**

The form work for shell shall be capable of adjusting to shell profile and thickness accurately, and rigidly braced to prevent deflection or movement during concreting.

The form work shall be rigid, shape preserving , tight fitting and easy to construct so as to ensure smooth concrete surfaces, no geometrical discontinuities and achieve a high degree of dimensional accuracy.

Check for absolute positions may be carried out from ground stations arranged at not more than 10 degree plan angle apart. Readings of horizontal radius shall be taken at every lift.

The shell shall be constructed within the dimensional tolerances as stipulated in clause 7.3 of IS: 11504. If the permissible dimensional tolerance are exceeded, the Owner will instruct the contractor, in writing, to stop construction of the shell. The Contractor shall then examine the situation and

Submit a report to the Owner who may require the contractor to demonstrate by calculations that the structural integrity of the shell will not be impaired as a result of the imperfections. The calculations shall be submitted to the Owner, for approval, before construction will be permitted to proceed.

If in the opinion of the Owner the calculations show that the integrity of the shell could be threatened, the Contractor will be required to submit to the Owner detailed arrangement and supporting calculations to set right the shell geometry for approval, before construction will be permitted to proceed.

The cost of carrying out the calculation, any remedial work required and idle time or any delays to the construction programme as a result of dimensional tolerances being exceeded will be borne by the contractor.

Adjustment to the tower shell line on the basis of the survey results shall be made gradually; limiting the maximum change of direction from the existing vertical shell profile to be not more than an angular change of 10 mm measured over 1m of height. Any such adjustment shall be made with full knowledge and consent of the Owner.

The contractor shall carry out an as-built -survey of each lift of the shell. The results of these checks will be recorded on a suitably developed drawing of the shell from which it will be possible to locate the survey check point. A copy of these results will be presented to the Owner prior to commencing the next shell pour.

The contractor's shell construction procedures shall include for providing the Owner with the facilities and a reasonable time period as may be required to carry out an independent check of the completed works.

Suitable communication system such as telephone, wireless equipments, etc. shall be provided by the contractor so that the communications are possible at different elevations of the tower from the ground during construction.

All piling work shall be carried out by specialist subcontractor approved by the Owner. Initial pile load test shall be carried out for at least 3 sets of piles for direct compression and lateral load.

Since the effective action of the piles will depend on the adopted method of construction, the contractor shall guarantee that the piles, as constructed by the sub-contractor, shall effectively transmit the maximum loads which can be imposed on the foundation soil and corresponding maximum deflections.

9.09.0 **General Requirements**

a) The basin slab shall be divided into two equal parts by a partition wall designed to withstand full hydrostatic pressure, with one side empty. The basin construction joints shall be made watertight by injection of

Chemical grout through nipples. The basin construction shall be tested for water tightness, in accordance with IS: 3370 (Part I) (Latest edition). The cost of the test and any rectification and re- test if required is deemed to be included in the contractor's quoted price. Any cost of filling and emptying of the basin and to rectify defects shall also be borne by the contractor.

b) PVC water stops shall be provided at all construction/ expansion joints of water retaining structures. 230 mm (min) wide and 10 mm (min) thick approved quality PVC water stop with central bulb shall be used where expansion joints are envisaged.

c) The basin floor of each compartment shall be provided with a slope of not less than 1 in 120 towards sump for dewatering. From sump, the water will be drained by C.I. drain pipe, embedded below the basin floor, into a drain chamber outside the tower basin or as per the arrangements described elsewhere in the tender document. Suitable sluice gates (rising spindle type) conforming to IS: 3042 or sluice valves shall be provided in the drain chamber or any other arrangement specified elsewhere in the tender document. Suitable operating platform with access ladders for operating the gates or valves and pipes, shall be provided in the drain box.

d) A 250 mm high sill shall separate the pond floor from the tower outlet.

e) Uniform surface on the top of basin floor shall be provided. In case undulated surface is observed, a top of layer of minimum 25 mm thick 1.3 mix mortar to be provided to achieve uniform surface.

f) Fill will be of film type supported on RCC beam. Film fill should be characterized by reduced air pressure losses, and shall not susceptible to clogging. Design and facing of the film fill shall be such as to expose high air/water surface with minimum air pressure drop.

g) The sluice gates shall be structural steel with anti-corrosive coating specified elsewhere. Number of sluice gates and removable screen shall be two (2) per tower. Proper rubber seal shall be provided so as to avoid any leakage of water. The rubber seal provided for the sluice gates be tested in accordance with the relevant Indian Standard Code. Sluice gates shall be checked for water tightness and smooth operation in dry and wet conditions. Suitable facilities, as approved by the Owner, shall be provided for handling of sluice gates and screens.

h) Lean concrete below foundations, cold water basin, other liquid retaining structures and all underground structures, unless noted otherwise shall be at least 100 mm thick.

i) The R.C.C. structure of the Cooling Tower shall be painted on the

Exterior surface with two (2) coats of water proof cement paint of approved make and colour.

The interior surface of the Cooling Tower structure and the interior face of the Cooling Tower Basin, fill supporting beams, columns and bracings, raker columns etc. which are in contact with water / moisture shall be painted with one coat of primer and two coats water proof bituminous paint conforming to IS:3384 and IS:9862 respectively.

j) Unless noted otherwise all concrete surface which are in contact with the earth shall be applied with anticorrosive coat system.

k) Water proofing and plasticizer admixtures conforming to relevant IS codes may be added as per manufacturer's instruction to the concrete subject to approval of the Owner.

l) The tower shall be provided with two numbers external RC staircase, leading to a heavy duty door giving access to the distribution system. Staircase shall be minimum 1000 mm wide (clear), with landings of minimum width of 1000 mm at not more than 2500 mm height intervals unless approved otherwise. The stair shall have risers not exceeding 125 mm and treads 250 mm minimum. Anti-skid nosing at each step shall be provided.

m) Minimum size of all doors shall be 2100 mm high (clear) and 1200 mm wide (clear). The door shall be of steel with anti-corrosive coating of polyurethane as specified elsewhere. However, FRP material or equivalent may also be used subject to approval of the Owner. The door shall be air tight when closed.

n) The hand railing on both sides of the staircase shall be galvanized with three rails of 32 mm NB pipes conforming to medium class as per IS:1239, and posts conforming to medium class as per IS:1239 of 32 mm dia galvanized pipes spaced not more than 1.2 m centers. The top hand rail shall be at 1000 mm above the steps with an intermediate member at 550 mm height. The posts and runners shall be welded construction with round corners. Complete hand rail shall be applied with anticorrosive coating system as specified elsewhere. All galvanization works shall have 610 gm/sqm of deposit.

o) Approved walkways and platforms shall be provided inside the tower at distribution pipe level. These walkways and platforms shall provide safe and clear access to all sprayers and all distribution pipes. The clear width of walkway shall be 1.5m and clear head room shall not be less than 2 m. Radial gaps of 12 mm wide shall be provided at intervals in the walkways for discontinuity.

A reinforced concrete platform of 1500 mm clear width shall be provided around the tower valves. Other walkways shall be at least 600 mm wide with 50 mm (minimum) safety kerbs along each edge. Access ways shall be clear of all obstructions such as distribution pipe support beams, drift eliminator support beams etc. The walkways shall be provided with transverse slots or other opening which will permit the free passage of air and water.

p) Hot double dip galvanized handrails as described above shall be provided on all sides where there is a risk of falling through the fill.

q) Reinforced concrete platforms 1.2 m clear width all around the tower circumference shall be provided on the tower for fixing of aviation warning light at levels specified elsewhere. 12 mm wide radial gaps shall be provided in the platform at suitable intervals for discontinuity. Adequate MS embedment shall be provided in each side of platform to facilitate maintenance of tower shell.

Two (2) diametrically opposite galvanized MS caged ladders, 600 mm wide, made out of 6 mm, x 10 mm flats for full height of the tower shall be provided as per IS: 3696.

r) MS rung ladders shall be hot dip galvanized ladder shall be 600 mm wide fabricated out of 60 mm x 10 mm flats with 20 mm dia. rungs at 300 mm centers. Stays shall be provided at every 2.25 m intervals connecting the ladder with the concrete shell. Upto throat level these ladders shall be on the exterior surface of the cooling tower and shall be continued along the inside surface of the tower up to the top of the tower.

Galvanised MS Safety cage shall be provided for all ladders and shall be fabricated out of 5 nos. verticals of 50 mm x 6 mm flats with 50 mm x 6 mm flat straps at 800mm centers.

A RCC landing of size not less than 750 mm x 1500 mm, with galvanized handrails and galvanized steel door to be provided at the throat for interchange. Intermediate landings of reinforced concrete of size not less than 750 mm x 1500 mm shall be provided at every 8 to 10 m height of the ladder.

Some of these landing levels shall be suitably adjusted to give access to aviation warning beacons for maintenance. Handrails as described above shall be provided on all platforms. The ladder leading to the top platform shall have approach from ground via the RCC staircase.

s) In order to provide approach for maintenance of shell (inside & outside faces), all platforms shall have 20 mm wide radial openings in the platform floor at locations approved by Owner. Adequate numbers of 75 mm internal diameter puddle flanged C.I. pipes shall be embedded in this platform for passing ropes during maintenance of tower shell.

t) All exposed structural steel work used in cooling towers shall be hot double dip galvanized unless it is coated with a separate anti-corrosive coating system. The minimum coating shall be 610 gm/sq.m and shall comply with relevant IS codes. Galvanizing shall be checked and tested in accordance with IS: 2629.Galvanization shall be followed by the application of an etching primer and anticorrosive hibuild epoxy coating system of DFT 260 microns. All welding shall be done before galvanizing. Any site joints required to be carried out after galvanizing shall be either flanged or screwed joints. Nails, nuts, bolts and all components coming in direct contact with water shall be of stainless steel of AISI 304 or equivalent.

u) Mix proportion in Cement-sand mortar for brick masonry work shall be 1:6 for 250 mm thick brickwork and cement-sand mortar (1:6) shall be used for 125 mm and 75 mm thick brickwork. Thickness of 1:6 cement-sand plaster on brick masonry shall be 18 mm for outside, 12 mm for inside and thickness of 1:4 cement-sand plaster shall be 6 mm for ceiling.

v) Materials for precast concrete components including joint fixing, lifting hooks and other exposed steel components shall conform to technical specification and other points mention in the document.

9.10.0 Grating

Steel gratings, where required, shall be fabricated out of steel flats with minimum thickness of 6 mm. Thickness of fabricated grating shall be 32 mm with flats so arranged as to have a maximum opening of 25 mm or less. Treads for staircases, where needed, shall be of similar grating construction but provided with toe flats of 6 mm thick, and non-skid nosing in an approved manner extending up to 100 mm above the walkway surface. All steel gratings shall be galvanized and applied with anticorrosive coating specified elsewhere.

9.11.0 Paving

The finished ground level shall be paved for 3.0m width all-round the outer edge of the cold water basin. The paving shall consist of 150 thick RCC slab of M-20 grade over soling. The minimum reinforcement shall be 10 mm dia spaced 150 mm center to center both ways top and bottom. The RCC slab shall be overlaid 100 mm thick M-10 PCC mat and 300 mm well compacted

Sand layer. All around peripheral RCC drain leading to drain chamber shall be suitably provided.

9.12.0 **Fittings and fixtures**

a) Complete system of Lightning protection, Aviation warning lights and Access ladder to be provided as per Clause 7.5 of IS 11504 (latest).

10.00.0 DELETED

11.00.0 **TESTING AND INSPECTION**

11.01.0 **Test at Manufacture's work**

11.01.1 The manufacturer shall conduct all tests required to ensure that the equipment furnished shall conform to the requirements of this specification and shall be in compliance with requirements of applicable codes and standards.

11.01.2 The particulars of the proposed tests and the procedures for the tests shall be submitted to the Purchaser/Consultant for approval before conducting the tests.

11.01.3 Inspection shall be conducted by the manufacturer to establish and maintain quality of workmanship, to ensure mechanical accuracy of components, compliance with drawings, identity & acceptability of all material, part and equipment. Where specified, all such inspections shall be conducted in presence of Purchaser's representatives.

11.01.4 The Bidder shall submit to the Purchaser/Consultant at the initiation of the contract, the detailed bar chart showing the manufacturing program and indicating the period when Purchaser or his authorized inspecting agency are required at the shop for inspection and/or testing. Also, the manufacturer shall intimate the Purchaser 3 to 4 weeks in advance of such tests. The Purchaser/Consultant shall be given full access to all tests and inspection.

11.01.5 All materials used for cooling tower construction shall be of tested quality. Materials shall be tested as per the relevant standards or codes and test certificates shall be made available to the Purchaser/Consultant.

11.01.6 Where stage inspection is specified, all material test certificates shall be correlated and verified with the actual material used for construction before starting fabrication by Purchaser's inspector who shall stamp the material. In case mill test certificates for the material are not available, the supplier shall

Carry out physical and chemical tests at his own cost from a testing agency, approved by the Purchaser, as per the requirements of specified material standard. The samples for physical and chemical testing shall be drawn up in presence of Purchaser's inspector who shall also witness the testing.

11.01.7 Hydrostatic testing for hot water distribution piping shall be at a pressure of 200% of design pressure after fabrication at shop.

11.01.8 Butterfly valves shall be tested as per the stipulations of AWWA C- 504, latest edition.

11.02.0 **Tests at Site**

11.02.1 After completion of construction, erection and commissioning of the cooling tower, performance test of the cooling tower shall be carried out as specified in Data Specification Sheet in accordance with Cooling Tower Institute Bulletin No. ATC-105 "Acceptance Test Procedure for Water Cooling Tower" or ASME (USA) performance test code PTC: 23 or other equivalent mutually agreed method. The details of the proposed test procedure shall be submitted by the supplier sufficiently in advance of the commencement of test for the review and approval of the Purchaser.

11.02.2 Necessary correction curves required for correcting the test results for any difference between test and guaranteed design conditions shall be furnished by the supplier for approval along with the proposed test procedure.

11.02.3 All testing and calibrating instruments required for site performance tests shall be arranged by the cooling tower supplier without any extra cost.

12.00.0 **PERFORMANCE GUARANTEES**

12.01.0 Each equipment shall be guaranteed to meet the performance requirements as specified. If during the performance testing of the tower, the actual cooling water temperature obtained is higher than the guaranteed cooling water temperature (obtained from the performance curve) corresponding to the flow, wet bulb temperature, relative humidity and cooling range prevailing during the test, the contractor shall satisfactorily rectify all defects within scheduled time period.

12.02.0 After the tests conducted at the Manufacturer's works in accordance with this specification, rectification of any defect observed shall be satisfactorily done without charging any extra cost to the Owner.

12.03.0 The performance test shall be carried out at site as specified and all defects shall be satisfactorily rectified within scheduled time period. No extra cost shall be charged to the Owner for such rectification. After rectification, retesting will be done by Bidder without any extra cost to Owner till

Satisfactory performance is achieved.

12.04.0 The bidder shall guarantee that the cooling towers offered shall meet the ratings and performance requirements stipulated in this specification. The bidder shall also furnish a declaration for certain guaranteed parameters like "Fulfillment of cold water temperature" which shall attract levees of liquidated damages for shortfall in performance. In case the contractor does not fulfill the guaranteed parameters, purchaser may undertake to rectify the system/equipment and expenditure incurred along with any other incidentals shall be recovered from the contractor.

13.00.0 **DRAWINGS/DOCUMENTS, DATA & INFORMATION TO BE FURNISHED BY THE BIDDER ALONG WITH THE TECHNICAL OFFER**

13.01.0

13.01.1

DELETED

13.01.2

13.01.3 Cooling Tower Manufacturer's detailed literature including drawing and diagram for :

a) Tower fills with supporting arrangement.

b) Drift eliminator.

c) Complete distribution system including regulating type water distribution valves, distribution basin/pipes, orifices/ nozzles, etc.

13.01.4 DELETED

13.01.5 A detailed experience list about supply of similar plant by the Bidder/ Manufacturer and his collaborator.

13.01.6 A comprehensive write-up or Brochure on the details of manufacturing and testing facilities in the shop of Manufacturer.

13.01.7 All other relevant data and drawings as asked for in the specification and as

required.

13.01.8 A sample of the fill material to be used for the specified cooling tower.

13.01.9 Bidder's proposal covering chemical treatment of cooling water to minimize biological fouling, scaling and corrosion as well as for containing concentration factor.

14.00.0 **DRAWINGS/DOCUMENT, DATA, A ND MA NUAL TO BE FURNISHED AFTER AWARD OF CONTRACT**

14.01.0

14.02.0

14.02.1

DELETED

14.02.2

14.02.3

14.02.4 Following drawings on mechanical equipment, their drives and accessories:

i) Fabrication and piping erection drawing.

ii) Outline and sectional drawings of valves of each category indicating also material of construction.

iii) Drawing on fill, drift eliminator and its support systems and fastening arrangement complete with data on material of construction.

iv) Drawing on splash boxes, nozzles in hot water basin, with data on material of construction.

v) Drawings on screens & gates with material of construction.

14.02.5 DELETED

14.02.6 Detail technical particulars of equipment and materials under the scope of this specification.

14.02.7 **Drawings, Data and Calculation on Civil works**

i)

ii) DELETED

iii)

iv) Bar bending details for all reinforced concrete structures.

v) Insert details, anchor bolt details.

vi) Final painting schedule.

vii) Other drawings & data as necessary.

14.03.0 The Documents to be submitted before dispatch of Equipment for approval

14.03.1 Material Test Certificate for mechanical equipment.

14.03.2 Certificates on treatment done on timber components.

14.03.3 Test certificates on each electrical equipment, cables and accessories.

14.03.4 **Instruction Manuals**

i) The Instruction Manuals shall present the following basic categories of information in practical, complete and comprehensive manner prepared for use by operating and/or maintenance personnel :

- Instruction for initial installation of mechanical and electrical equipment.
- Instructions for operation, control, monitoring and protection.
- Instruction for maintenance, overhaul and replacement of parts etc.
- Recommended inspection points & periods of inspection.
- Lubrication Chart.
- Ordering information for all replaceable parts, etc.

- Write-up, leaflet/catalogue etc. covering equipment features.

ii) The information shall be organized in a logical and orderly sequence. A general description of the equipment including significant technical characteristics is required to familiarize operating and maintenance personnel with the equipment.

iii) Necessary drawings and/or other illustrations shall be included or copies of appropriate certified drawings shall be bound in the manual. Test, adjustment and calibration information, as appropriate, shall be included and shall be identified to the specific equipment. Safety and other warning notices and installation, maintenance and operating cautions shall be emphasized.

iv) A parts list shall be included showing part nomenclature, manufacturer's part number and/or other information necessary for accurate identification and ordering of replacement parts.

v) Instruction and part list shall be legible and prepared on good quality paper.

vi) The Instruction Manual shall be securely bound in durable folder.

vii) If a standard manual is furnished covering more than the specific equipment purchased, the applicable model (or other identification) number, part number and other information for the specific equipment purchased shall be clearly identified.

viii) The Instruction Manual shall include list of all special tools and tackle furnished with complete drawing and instruction for use of such tools and tackle.

GEOTECHNICAL INVESTIGATION REPORT

PROJECT: 5X800 MW YADADRI TPS, NALGONDA

Part 1 - MAIN PLANT AREA

Volume I

DOCUMENT NO: PE-DC-417-602-C001

Customer

TELANGANA STATE POWER GENERATION CORPORATION Ltd.

Submitted by

Maharatna Company

PROJECT ENGINEERING MANAGEMENT

POWER PROJECT ENGINEERING INSTITUTE

HRD & ESI COMPLEX

PLOT NO.: 25, SECTOR-16A

NOIDA (U.P.) - 201 301

REPORT ON
GEOTECHNICAL INVESTIGATION WORK
AT 5X800 MW YADADRI TPS, NALGONDA
TELANGANA

PART 1: MAIN PLANT AREA
(Volume I: Methodology, Analysis & Recommendations)

Client:

M/s. Bharat Heavy Electricals Limited

Consultants:

Noble Geo-Structs
Dr. R.P. Road, 6 Satyam
Near Johnson & Johnson, Mulund
Mumbai, M.H. 400080, India
O 91-22-25915274 | F 91-22-21639700 | C 91-9820285809
info@noblegeostructs.com | www.noblegeostructs.com

14.0 SUMMARY & CONCLUSIONS

Based on the field and laboratory tests and the foregoing discussion the following are summarised.

1. In general the substrata is characterized by completely to highly weathered rock in the top horizon followed by fresh rock continues up to the terminating depth of all the boreholes. However at few locations, stiff silty clay/clayey silt layer is observed up to about 1.5m depth below EGL.
2. The standing water level was found from 2.0m to 6.50m depth below existing ground level. However in some borehole water table is not encountered.
3. Considering the sub strata condition and the proposed structure to be constructed at the present site, it is suggested to go for open foundation.
4. Minimum depth of foundation shall be 1.0m below EGL in case of soil strata. For rocky strata minimum depth of foundation shall be 0.6m below EGL.
5. The sample calculation for net safe bearing capacity values with various depth of foundation are presented in the previous section. The net safe bearing capacity (SBC) for all type of foundations shall be taken from approved soil investigation report.
6. Chemical tests were carried out on some soil and water samples so as to detect the pH value, Sulphate, Chloride etc. It is seen that the values are within permissible limits. So, no special cement/reinforcement steel will be required for foundation concrete.
7. The sub strata at site consists of silty clay/ completely weathered rock having low swelling properties. So, the excavated soil/weathered rock is suitable for filling and backfilling purposes.

8. Bore logs, Trial Pits (TP), Laboratory test results on soil & rock samples, Standard & Modified proctor test, Chemical test on soil and water samples and CBR test results are presented in volume-II.
9. Plate load test (PLT), Cyclic plate load test (CPLT), Cross hole shear test (CST), Pressure meter test (PMT), Electrical resistivity test (ERT), Block vibration test (BVT) and Seismic refraction test (SRT) are presented in volume-III.
10. For design of Machine foundations, Cross hole shear test results presented in volume III shall be referred.

Prepared by	Checked by	Approved by
Ms. Mohini Satam	Mr. S.R.Kulkarni	Dr. U.V.Kulkarni
Mgr. (Geotech)	Sr. Mgr. (Geotech)	Director
M/s Noble Geo- Structs	M/s NGS Noble Geo- Structs	M/s Noble Geo- Structs

BH NO. :	113	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	82.125
LOCATION :	N= -129 E= -443	**WATER TABLE BELOW EGL (m) :**	3.80
		CASING DEPTH (m) :	1.00
START DATE :	17/04/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	20/04/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	82.13										
0.50	81.63										
1.00	81.38		Completely to Highly weathered pink grey, fine grained Quartzite	0.75						13	Nil
1.50	80.63			1.50						19	Nil
2.00	80.13										
2.50	79.88			2.25						21	Nil
3.00	79.13			3.00						21	Nil
3.50	78.63		Highly weathered pink grey, fine grained Quartzite								
4.00	78.38			3.75						22	Nil
4.50	77.63		Highly weathered pink grey, fine grained Limestone	4.50						23	Nil
5.00	77.13		Highly weathered grey, fine grained Quartzite								
5.50	76.88			5.25						21	Nil
6.00	76.13			6.00						23	Nil
6.50	75.63		Moderately weathered grey, fine grained Quartzite								
7.00	75.38			6.75						35	Nil
7.50	74.63			7.50						35	Nil
8.00	74.13										
8.50	73.63			8.25						28	Nil
9.00	73.13			9.00						40	Nil
9.50	72.63										
10.00	72.13			9.75						30	Nil

BH NO. :	113	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	82.125
LOCATION :	N= -129 E= -443	**WATER TABLE BELOW EGL (m) :**	3.80
		CASING DEPTH (m) :	1.00
START DATE :	17/04/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	20/04/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
10.50	71.63			10.50						26	Nil
11.00	71.13										
11.50	70.63			11.25						28	Nil
12.00	70.13		Moderately weathered black, fine grained Shale	12.00						21	Nil
12.50	69.63										
13.00	69.13			12.75						26	Nil
13.50	68.63			13.50						28	Nil
14.00	68.13										
14.50	67.63			14.25						40	Nil
15.00	67.13			15.00						42	13

THE BOREHOLE IS TERMINATED AT 15.00m BELOW G.L.

BH NO. :	115	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	81.570
LOCATION :	N= -196 E= -461	**WATER TABLE BELOW EGL (m) :**	3.80
		CASING DEPTH (m) :	1.50
START DATE :	12/04/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	14/04/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	81.57		Moderately weathered grey, fine grained Quartzite								
0.50	81.07										
1.00	80.82			0.75						21	Nil
1.50	80.07			1.50						24	Nil
2.00	79.57		Moderately weathered grey, fine grained Quartzite								
2.50	79.32			2.25						36	Nil
3.00	78.57			3.00						32	Nil
3.50	78.07										
4.00	77.82			3.75						44	13
4.50	77.07			4.50						40	17
5.00	76.57		Completely weathered grey, fine grained Quartzite								
5.50	76.32			5.25					R	16	Nil
6.00	75.57			6.00					R	8	Nil
6.50	75.07										
7.00	74.82			6.75					R	6	Nil
7.50	74.07			7.50					R	6	Nil
8.00	73.57		Slightly weathered greyish pink, fine grained Limestone								
8.50	73.07			8.25						41	Nil
9.00	72.57			9.00						41	Nil
9.50	72.07										
10.00	71.57			9.75						34	Nil
10.50	71.07			10.50						53	Nil
11.00	70.57										
11.50	70.07			11.25						50	Nil
12.00	69.57			12.00						49	Nil

BH NO. :	115	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	81.570
LOCATION :	N= -196 E= -461	**WATER TABLE BELOW EGL (m) :**	3.80
		CASING DEPTH (m) :	1.50
START DATE :	12/04/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	14/04/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
12.50	69.07										
13.00	68.57		Slightly weathered greyish pink, fine grained Limestone	12.75						60	42
13.50	68.07			13.50						46	34
14.00	67.57										
14.50	67.07			14.25						65	38
15.00	66.57			15.00						62	28
THE BOREHOLE IS TERMINATED AT 15.00m BELOW G.L.											

BH NO. :	116	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	81.570
LOCATION :	N= -214 E= -529	**WATER TABLE BELOW EGL (m) :**	4.30
		CASING DEPTH (m) :	1.50
START DATE :	15/04/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	17/04/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	81.57		Completely to Highly weathered grey, fine grained Quartzite								
0.50	81.07										
1.00	80.82			0.75	SPT1	>50			R	10	Nil
1.50	80.07			1.50	SPT2	>50			R	9	Nil
2.00	79.57										
2.50	79.32			2.25	SPT3	>50			R	16	Nil
3.00	78.57		Highly weathered grey, fine grained Quartzite	3.00						22	Nil
3.50	78.07		Moderately weathered grey, fine grained Quartzite								
4.00	77.82			3.75						29	16
4.50	77.07			4.50						28	17
5.00	76.57										
5.50	76.32			5.25						26	Nil
6.00	75.57			6.00						32	Nil
6.50	75.07										
7.00	74.82			6.75						26	Nil
7.50	74.07			7.50						32	17
8.00	73.57										
8.50	73.07			8.25						32	Nil
9.00	72.57			9.00						26	21
9.50	72.07		Fresh grey, fine grained Quartzite							44	18
10.00	71.57									32	Nil

THE BOREHOLE IS TERMINATED AT 10.00m BELOW G.L.

BH NO. :	117	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	81.210
LOCATION :	N = -246 E =-412	**WATER TABLE BELOW EGL (m) :**	5.00
		CASING DEPTH (m) :	1.50
START DATE :	16/01/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	19/01/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	81.21		Highly weathered grey, fine grained Quartzite								
0.50	80.71										
1.00	80.46			0.75						23	Nil
1.50	79.71			1.50						24	20
2.00	79.21		Moderately weathered grey, fine grained Quartzite								
2.50	78.96			2.25						32	Nil
3.00	78.21			3.00						25	Nil
3.50	77.71		Slightly weathered grey, fine grained Quartzite								
4.00	77.46			3.75						45	45
4.50	76.71			4.50						69	69
5.00	76.21										
5.50	75.96			5.25						45	Nil
6.00	75.21			6.00						44	32
6.50	74.71										
7.00	74.46			6.75						37	Nil
7.50	73.71			7.50						51	51
8.00	73.21		Moderately weathered grey, fine grained Quartzite								
8.50	72.96			8.25						39	13
9.00	72.21			9.00						37	20
9.50	71.71		Fresh grey, fine grained Quartzite								
10.00	71.46			9.75						87	41

BH NO. :	117	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	81.210
LOCATION :	N = -246 E =-412	**WATER TABLE BELOW EGL (m) :**	5.00
		CASING DEPTH (m) :	1.50
START DATE :	16/01/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	19/01/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration				Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm			SPT N value		
				m		15	30	45		%	%
10.50	70.71		Fresh grey, fine grained Shale	10.50						85	14
11.00	70.21										
11.50	69.71										
12.00	69.21			12.00						63	Nil
12.50	68.71										
13.00	68.21										
13.50	67.71			13.50						71	39
14.00	67.21										
14.50	66.71										
15.00	66.21			15.00						65	15

THE BOREHOLE IS TERMINATED AT 15.00m BELOW G.L.

BH NO. :	119	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	80.530
LOCATION :	N = -359 E = -443	**WATER TABLE BELOW EGL (m) :**	4.00
		CASING DEPTH (m) :	1.50
START DATE :	20/01/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	23/01/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration				Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm			SPT N value		
						15	30	45			
				m						%	%
0.00	80.53		Highly weathered pink, fine grained Limestone								
0.50	80.03										
1.00	79.78			0.75						24	Nil
1.50	79.03		Moderately weathered pink, fine grained Limestone	1.50						23	Nil
2.00	78.53										
2.50	78.28			2.25						27	13
3.00	77.53			3.00						49	34
3.50	77.03										
4.00	76.78			3.75						84	64
4.50	76.03			4.50						87	52
5.00	75.53										
5.50	75.03										
6.00	74.53			6.00						61	44
6.50	74.03		Fresh grey, fine grained Limestone								
7.00	73.53										
7.50	73.03			7.50						64	Nil
8.00	72.53										
8.50	72.03										
9.00	71.53			9.00						61	Nil
9.50	71.03										
10.00	70.53										

BH NO. :	119	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	80.530
LOCATION :	N = -359 E = -443	**WATER TABLE BELOW EGL (m) :**	4.00
		CASING DEPTH (m) :	1.50
START DATE :	20/01/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	23/01/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration				Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm			SPT N value		
				m		15	30	45		%	%
10.50	70.03		Fresh black, fine grained Shale	10.50						64	16
11.00	69.53										
11.50	69.03										
12.00	68.53			12.00						71	21
12.50	68.03										
13.00	67.53										
13.50	67.03			13.50						72	23
14.00	66.53										
14.50	66.03										
15.00	65.53			15.00						66	17

THE BOREHOLE IS TERMINATED AT 15.00m BELOW G.L.

BH NO. :	121	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	78.955
LOCATION :	N = -426 E = -461	**WATER TABLE BELOW EGL (m) :**	5.00
		CASING DEPTH (m) :	1.50
START DATE :	17/02/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	24/02/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	78.96		Highly Weathered grey, fine grained Fractured Quartzite								
0.50	78.46										
1.00	78.21			0.75						24	Nil
1.50	77.46			1.50						23	Nil
2.00	76.96										
2.50	76.71			2.25						29	Nil
3.00	75.96		Slightly Weathered grey, fine grained Quartzite	3.00						44	39
3.50	75.46										
4.00	75.21			3.75						47	36
4.50	74.46			4.50						83	71
5.00	73.96										
5.50	73.71			5.25						85	57
6.00	72.96										
6.50	72.46										
7.00	72.21			6.75						61	45
7.50	71.46										
8.00	70.96										
8.50	70.71			8.25						59	40
9.00	69.96		Slightly Weathered Dark Grey, fine grained Shale								
9.50	69.46										
10.00	69.21			9.75						59	15
10.50	68.46										
11.00	67.96										
11.50	67.71			11.25						47	13

BH NO. :	121	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	78.955
LOCATION :	N = -426 E = -461	**WATER TABLE BELOW EGL (m) :**	5.00
		CASING DEPTH (m) :	1.50
START DATE :	17/02/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	24/02/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
12.00	66.96		Fresh Dark grey, fine grained Shale								
12.50	66.46										
13.00	66.21			12.75						70	14
13.50	65.46										
14.00	64.96										
14.50	64.71			14.25						77	58
15.00	63.96			15.00						87	71

THE BOREHOLE IS TERMINATED AT 15.00m BELOW G.L.

BH NO. :	123	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	79.779
LOCATION :	N= -444 E= -529	**WATER TABLE BELOW EGL (m) :**	Not struck
		CASING DEPTH (m) :	NA
START DATE :	26/02/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	28/02/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	79.78		Slightly Weathered grey, fine grained Quartzite								
0.50	79.28										
1.00	79.03			0.75						41	Nil
1.50	78.28			1.50						45	Nil
2.00	77.78										
2.50	77.53			2.25						33	Nil
3.00	76.78			3.00						44	20
3.50	76.28										
4.00	76.03			3.75						52	Nil
4.50	75.28		Fresh grey, fine grained Quartzite	4.50						72	45
5.00	74.78										
5.50	74.53			5.25						70	Nil
6.00	73.78			6.00						50	33
6.50	73.28										
7.00	73.03			6.75						66	60
7.50	72.28			7.50						56	34
8.00	71.78										
8.50	71.53			8.25						64	40
9.00	70.78		Slightly Weathered grey, fine grained Quartzite	9.00						50	Nil
9.50	70.03			9.75						48	Nil
10.00	69.78			10.00						40	Nil
THE BOREHOLE IS TERMINATED AT 10.00m BELOW G.L.											

BH NO. :	124	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	77.977
LOCATION :	N = -476 E = -412	**WATER TABLE BELOW EGL (m) :**	Not struck
		CASING DEPTH (m) :	1.50
START DATE :	11/02/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	15/02/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	78.20		Light Brown Grit and fine grained Quartzite								
0.50	77.70										
1.00	77.45			0.75						23	Nil
1.50	76.70		Moderately weathered grey, fine grained Quartzite	1.50						27	13
2.00	76.20										
2.50	75.95			2.25						27	Nil
3.00	75.20			3.00						22	Nil
3.50	74.70										
4.00	74.45			3.75						21	13
4.50	73.70			4.50						33	23
5.00	73.20		Slighltly Weathered grey, fine grained Quartzite								
5.50	72.95			5.25						50	Nil
6.00	72.20			6.00						71	Nil
6.50	71.70		Moderately weathered grey, fine grained Quartzite								
7.00	71.45			6.75						33	Nil
7.50	70.70			7.50						39	Nil
8.00	70.20		Fresh grey, fine grained Quartzite								
8.50	69.95			8.25						93	Nil
9.00	69.20			9.00						92	Nil
9.50	68.70		Fresh black, fine grained Shale								
10.00	68.20										
10.50	67.70			10.50						70	17

BH NO. :	124	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	77.977
LOCATION :	N = -476 E = -412	**WATER TABLE BELOW EGL (m) :**	Not struck
		CASING DEPTH (m) :	1.50
START DATE :	11/02/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	15/02/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
11.00	67.20		Fresh Dark Gray, fine grained Shale								
11.50	66.70										
12.00	66.20			12.00						75	47
12.50	65.70										
13.00	65.20										
13.50	64.70			13.50						76	31
14.00	64.20										
14.50	63.70										
15.00	63.20			15.00						67	30

THE BOREHOLE IS TERMINATED AT 15.00m BELOW G.L.

BH NO. :	128	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	86.659
LOCATION :	N= -336 E= 1073	**WATER TABLE BELOW EGL (m) :**	4.50
		CASING DEPTH (m) :	
START DATE :	15/04/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	17/04/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	86.66		Highly weathered pink, fine grained Limestone								
0.50	86.16										
1.00	85.66			0.75						24	Nil
1.50	85.16		Moderately weathered pink, fine grained Limestone	1.50						29	13
2.00	84.66										
2.50	84.16			2.25						25	18
3.00	83.66		Slightly weathered pink, fine grained Limestone	3.00						46	46
3.50	83.16										
4.00	82.66			3.75						33	30
4.50	82.16			4.50						52	48
5.00	81.66										
5.50	81.16			5.25						58	50
6.00	80.66		Fresh pink, fine grained Limestone	6.00						70	14
6.50	80.16										
7.00	79.66			6.75						88	88
7.50	79.16			7.50						98	54
8.00	78.66										
8.50	78.16										
9.00	77.66			9.00						87	71
9.50	77.16										
10.50	76.16			10.25						74	55
11.00	75.66		Fresh pink grey, fine grained Limestone								
11.50	75.16										
12.00	74.66			12.00						77	35

BH NO. :	128	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	86.659
LOCATION :	N= -336 E= 1073	**WATER TABLE BELOW EGL (m) :**	4.50
		CASING DEPTH (m) :	
START DATE :	15/04/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	17/04/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration				Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm			SPT N value		
				m		15	30	45		%	%
12.50 13.00 13.50	74.16 73.66 73.16		Fresh grey, fine grained Limestone	13.50						80	47
14.00 14.50 15.00	72.66 72.16 71.66		Fresh grey, fine grained Limestone	15.00						68	24
THE BOREHOLE IS TERMINATED AT 15.00m BELOW G.L.											

BH NO. :	129	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	84.993
LOCATION :	N = -404 E = 1055	**WATER TABLE BELOW EGL (m) :**	4.00
		CASING DEPTH (m) :	
START DATE:	26/01/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	27/01/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	84.99										
0.50	84.49										
1.00	83.99			0.75						81	69
1.50	83.49			1.50						87	81
2.00	82.99										
2.50	82.49										
3.00	81.99		Fresh Pink grey, fine grained Limestone	3.00						77	74
3.50	81.49										
4.00	80.99										
4.50	80.49			4.50						80	68
5.00	79.99										
5.50	79.49										
6.00	78.99			6.00						48	36
THE BOREHOLE IS TERMINATED AT 6.00m BELOW G.L.											

BH NO. :	130	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	85.196
LOCATION :	N = -422, E=987	**WATER TABLE BELOW EGL (m) :**	5.50
		CASING DEPTH (m) :	
START DATE :	14/12/2015	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	15/12/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	85.20										
0.50	84.70										
1.00	84.20			0.75						85	29
1.50	83.70			1.50						95	48
2.00	83.20										
2.50	82.70										
3.00	82.20			3.00						78	47
3.50	81.70										
4.00	81.20										
4.50	80.70		Fresh pink grey, fine grained fractured limestone	4.50						93	43
5.00	80.20										
5.50	79.70										
6.00	79.20			6.00						82	35
6.50	78.70										
7.00	78.20										
7.50	77.70			7.50						83	30
8.00	77.20										
8.50	76.70										
9.00	76.20			9.00						87	58
9.50	75.70										
10.00	75.20			10.00						56	33

THE BOREHOLE IS TERMINATED AT 10.00m BELOW G.L.

BH NO. :	131	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	84.562
LOCATION :	N = -453 E = 1104	**WATER TABLE BELOW EGL (m) :**	5.00
		CASING DEPTH (m) :	
START DATE :	20/12/2015	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	21/12/2015	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration				Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm			SPT N value		
						15	30	45			
				m						%	%
0.00	84.56		Moderately weathered pink grey, fine grained Limestone								
0.50	84.06										
1.00	83.56			0.75						31	Nil
1.50	83.06			1.50						35	13
2.00	82.56		Fresh pink grey, fine grained Limestone								
2.50	82.06			2.25						95	80
3.00	81.56			3.00						87	44
3.50	81.06										
4.00	80.56										
4.50	80.06			4.50						80	60
5.00	79.56										
5.50	79.06										
6.00	78.56			6.00						76	73
6.50	78.06										
7.00	77.56										
7.50	77.06			7.50						87	44
8.00	76.56										
8.50	76.06										
9.00	75.56			9.00						90	82
9.50	75.06										
10.00	74.56			10.00						76	44

THE BOREHOLE IS TERMINATED AT 10.00m BELOW G.L.

BH NO. :	143	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	83.725
LOCATION :	N = -543 E = 888	**WATER TABLE BELOW EGL (m) :**	Not struck
		CASING DEPTH (m) :	
START DATE :	14/12/2015	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	13/12/2015	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	83.725		Slightly weathered pink grey, fine grained fractured limestone								
0.50	83.225										
1.00	82.725			0.75						47	17
1.50	82.225		Fresh pink grey, fine grained fractured limestone	1.50						80	17
2.00	81.725										
2.50	81.225			2.25						93	56
3.00	80.725										
3.50	80.225										
4.00	79.725			3.75						72	13
4.50	79.225										
5.00	78.725										
5.50	78.225			5.25						83	38
6.00	77.725										
6.50	77.225										
7.00	76.725			6.75						86	45
7.50	76.225										
8.00	75.725										
8.50	75.225			8.25						78	38
9.00	74.725										
9.50	74.225			9.75						84	68
10.00	73.725			10.00						78	Nil

THE BOREHOLE IS TERMINATED AT 10.00m BELOW G.L.

BH NO. :	144	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	84.172
LOCATION :	N = -564 E =1117	**WATER TABLE BELOW EGL (m) :**	Not struck
		CASING DEPTH (m) :	
START DATE :	12/08/2015	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	12/10/2015	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	84.17		Moderately Weathered grey red, fine grained limestone								
0.50	83.67										
1.00	83.42			0.75						37	Nil
1.50	82.67			1.25						47	Nil
2.00	84.17										
2.50	81.67		Fresh grey red, fine grained limestone	2.25						83	27
3.00	81.17			3.00						89	41
3.50	80.67										
4.00	84.17										
4.50	79.67			4.50						78	19
5.00	84.17										
5.50	78.67										
6.00	78.17			6.00						85	27
6.50	77.67										
7.00	84.17										
7.50	76.67			7.50						88	23
8.00	84.17										
8.50	75.67										
9.00	75.17			9.00						94	13
9.50	74.67										
10.00	74.17			10.00						87	29

THE BOREHOLE IS TERMINATED AT 10.00m BELOW G.L.

BH NO. :	145	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	83.145
LOCATION :	N = -611,E =870	**WATER TABLE BELOW EGL (m) :**	Not struck
		CASING DEPTH (m) :	
START DATE :	12/11/2015	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	13/12/2015	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration				Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm			SPT N value		
						15	30	45			
				m						%	%
0.00	83.15		Slightly weathered pink, fine grained limestone								
0.50	82.65										
1.00	82.40			0.75						53	15
1.50	81.65		Fresh pink grey, fine grained limestone	1.50						82	69
2.00	83.15										
2.50	80.65			2.25						81	43
3.00	83.15										
3.50	79.65										
4.00	79.40			3.75						71	22
4.50	78.65										
5.00	83.15										
5.50	77.65			5.25						75	25
6.00	83.15										
6.50	76.65										
7.00	76.40			6.75						74	41
7.50	75.65										
8.00	83.15										
8.50	74.65			8.25						80	9
9.00	83.15										
9.50	73.65										
10.00	73.40			9.75						77	33
10.50	72.65										
11.00	83.15										
11.50	71.65			11.25						85	43
12.00	83.15										

BH NO. :	145	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	83.145
LOCATION :	N = -611,E =870	**WATER TABLE BELOW EGL (m) :**	Not struck
		CASING DEPTH (m) :	
START DATE :	12/11/2015	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	13/12/2015	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
12.50	70.65		Fresh pink grey, fine grained limestone								
13.00	70.40			12.75						67	34
13.50	69.65										
14.00	83.15										
14.50	68.65			14.25						73	Nil
15.00	68.15			15.00						63	Nil

THE BOREHOLE IS TERMINATED AT 15.00m BELOW G.L.

BH NO. :	146	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	82.36
LOCATION :	N = -629 E = 802	**WATER TABLE BELOW EGL (m) :**	Not stuck
		CASING DEPTH (m) :	
START DATE :	12/12/2015	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	13/12/2015	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample Depth (m)	Sample Type	Penetration cm 15	Penetration cm 30	Penetration cm 45	SPT N value	Core Recovery (CR) %	Rock Quality Designation (RQD) %
0.00	82.36		Moderately wetahered pink grey, fine grained limestone								
0.50	81.86										
1.00	81.61			0.75						30	13
1.50	80.86		Fresh pink grey, fine grained limestone	1.50						83	46
2.00	82.36										
2.50	79.86			2.25						81	49
3.00	82.36										
3.50	78.86										
4.00	78.61			3.75						81	37
4.50	77.86		Fresh pink grey, fine grained fractured limestone								
5.00	82.36										
5.50	76.86			5.25						55	17
6.00	82.36										
6.50	75.86			6.75						74	34
7.00	82.36										
7.50	74.86										
8.00	82.36										
8.50	73.86			8.25						80	37
9.00	82.36										
9.50	72.86			9.75						89	55
10.00	72.36			10.00						96	Nil

THE BOREHOLE IS TERMINATED AT 15.00m BELOW G.L.

BH NO. :	147	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	83.767
LOCATION :	N = -631 E =1099	**WATER TABLE BELOW EGL (m) :**	Not struck
		CASING DEPTH (m) :	
START DATE :	12/07/2015	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	12/09/2015	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	83.77		Highly weathered pink, fine grained fractured limestone								
0.50	83.27										
1.00	83.02			0.75						23	Nil
1.50	82.27		Fresh pink grey, fine grained fine grained limestone	1.50						96	79
2.00	83.77										
2.50	81.27			2.25						89	33
3.00	83.77										
3.50	80.27										
4.00	80.02			3.75						96	70
4.50	79.27										
5.00	83.77										
5.50	78.27			5.25						74	30
6.00	83.77										
6.50	77.27										
7.00	77.02			6.75						77	40
7.50	76.27										
8.00	83.77										
8.50	75.27			8.25						40	15
9.00	83.77										
9.50	74.27										
10.00	74.02			9.75						61	20
10.50	73.27										
11.00	83.77										
11.50	72.27			11.25						66	26
12.00	83.77										

BH NO. :	147	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	83.767
LOCATION :	N = -631 E =1099	**WATER TABLE BELOW EGL (m) :**	Not struck
		CASING DEPTH (m) :	
START DATE :	12/07/2015	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	12/09/2015	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
12.50	71.27		Fresh pink grey, fine grained fine grained limestone								
13.00	71.02			12.75						71	53
13.50	70.27										
14.00	83.77										
14.50	69.27			14.25						72	38
15.00	68.77			15.00						70	59

THE BOREHOLE IS TERMINATED AT 15.00m BELOW G.L.

BH NO. :	148	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	83.044
LOCATION :	N = -660,E= 919	**WATER TABLE BELOW EGL (m) :**	Not struck
		CASING DEPTH (m) :	3.00
START DATE :	12/11/2015	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	12/12/2015	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	83.04										
0.50	82.54			0.50							
1.00	82.29			0.75						51	23
1.50	81.54			1.50						70	35
2.00	81.04										
2.50	80.79			2.25						85	50
3.00	80.04									97	43
3.50	79.54										
4.00	79.29			3.75							
4.50	78.54									80	42
5.00	78.04		Fresh pink grey, fine grained limestone								
5.50	77.79			5.25							
6.00	77.04									88	37
6.50	76.54										
7.00	76.29			6.75							
7.50	75.54									75	74
8.00	75.04										
8.50	74.79			8.25							
9.00	74.04									89	78
9.50	73.29			9.75							
10.00	73.04			10.00						81	81

THE BOREHOLE IS TERMINATED AT 10.00m BELOW G.L.

BH NO. :	149	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	83.576
LOCATION :	N = -649 E = 1031	**WATER TABLE BELOW EGL (m) :**	Not struck
		CASING DEPTH (m) :	
START DATE :	12/07/2016	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	12/09/2016	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	83.58		Highly weathered grey, fine grained Limestone								
0.50	83.08			0.50	DS1						
1.00	82.83			0.75						21	Nil
1.50	82.08		Fresh pink grey, fine grained Limestone	1.50						81	64
2.00	83.58										
2.50	81.08			2.25						93	79
3.00	83.58										
3.50	80.08										
4.00	79.83			3.75						73	39
4.50	79.08										
5.00	83.58										
5.50	78.08			5.25						68	41
6.00	83.58										
6.50	77.08										
7.00	76.83			6.75						81	37
7.50	76.08										
8.00	83.58										
8.50	75.08			8.25						75	33
9.00	83.58										
9.50	74.08			9.75						71	40
10.00	73.58			10.00						72	Nil

THE BOREHOLE IS TERMINATED AT 10.00m BELOW G.L.

BH NO. :	151	**EGL(EXISTING GROUND LEVEL) R.L.(+)m**	83.476
LOCATION :	N = -681 E = 1148	**WATER TABLE BELOW EGL (m) :**	Not struck
		CASING DEPTH (m) :	
START DATE :	12/04/2015	**BORING/ DRILLING METHOD :**	Rotary
END DATE :	12/06/2015	**DRILLING :** NX SIZE double tube core barrel	

Depth,m	RL, m	Graphical Log	Description	Sample		Penetration			SPT N value	Core Recovery (CR)	Rock Quality Designation (RQD)
				Depth	Type	cm					
						15	30	45			
				m						%	%
0.00	83.48		Highly weathered pink, fine grained Limestone								
0.50	82.98										
1.00	82.48			0.75						24	Nil
1.50	81.98		Fresh pink grey, fine grained Limestone	1.50						68	34
2.00	81.48										
2.50	80.98			2.25						90	Nil
3.00	80.48			3.00						86	77
3.50	79.98										
4.00	79.48										
4.50	78.98			4.50						100	21
5.00	78.48										
5.50	77.98										
6.00	77.48			6.00						74	31
6.50	76.98										
7.00	76.48										
7.50	75.98			7.50						22	Nil
8.00	75.48										
8.50	74.98										
9.00	74.48			9.00						73	41
9.50	73.98										
10.00	73.48			10.00						95	80

THE BOREHOLE IS TERMINATED AT 10.00m BELOW G.L.

CONTENTS

SECTION	DESCRIPTION	PAGE NOS.
SECTION-A	EARTHWORK IN EXCAVATION AND BACKFILLING	22 TO 37
SECTION-B	CEMENT CONCRETE (PLAIN & REINFORCED)	38 TO 80
SECTION-C	ROOF AND UNDERGROUND WATER PROOFING, INSULATION AND ALLIED WORKS	81 TO 90
SECTION-D	MISCELLANEOUS METAL	91 TO 96
SECTION-E	PAINTING, WHITE WASHING, POLISHING, ETC.	97 TO 104
SECTION-F	FABRICATION OF STRUCTURAL STEEL WORK	105 TO 135
SECTION-G	ERECTION OF STRUCTURAL STEEL WORK	136 TO 149
SECTION-H	SITE LEVELLING AND GRADING	150 TO 161
SECTION-I	SPECIAL CIVIL ITEMS FOR NDCT SHELL	162 TO 167

The following are the additional technical specifications for NDCTs. In the event of any contradictions or conflict between these specifications and those of TSGENCO, the TSGENCO specifications shall prevail over the additional specifications.

SECTION-A: 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 vegetation, 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, Murum 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, vegetation, 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 equipment 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 up to 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 murum, 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 murum 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 chiseling, 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 be 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 up to 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 license from the District Authorities for undertaking the blasting work as well as for obtaining and storing the explosives as per Explosives Rules, 1940 corrected up to 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.

d.) 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 off 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 vegetation, 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 up to 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, murum, 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, equipment, 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 from ground level, 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/excess excavation beyond this limit shall be at the risk and cost of the contractor and shall not be measured for payment for item of work on excavation, backfilling, carriage, dewatering etc. Required shoring & strutting, side slopes, benching, dewatering sump pits, approaches to the excavated pit etc. are deemed to be included in the quoted rates 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 from ground level, 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/excess excavation beyond this limit shall be at the risk and cost of the contractor and shall not be measured for payment for item of work on excavation, backfilling, carriage, dewatering etc. Required shoring & strutting, side slopes, benching, dewatering sump pits, approaches to the excavated pit etc. are deemed to be included in the quoted rates in the schedule of quantities.

e) 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.

f) 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.

g) The authorized quantity (calculated on the basis of authorized width/ working space under clause no. 5.2.0 c & 5.2.0 d) or those actually excavated, whichever, are less, shall be measured for payment.

h) 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.

.0.0 INFORMATION TO BE SUBMITTED BY THE BIDDER

6.1.0 With Tender

Detail of equipment 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.

SECTION – B: CEMENT CONCRETE (PLAIN AND 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

Cement and HYSD/HCRM reinforcement bars will be provided by BHEL to the contractor at free of cost.

No other 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. Cement will be supplied by BHEL to the contractor free of cost.

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. Reinforcement bars of HYSD/HCRM will be supplied by BHEL free of cost to the contractor. Mild steel bars, if required, shall be procured by the contractor.

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. Grade of concrete for cover blocks shall be one grade higher than the grade of concrete intended for use.

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 Design Mix 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 higher of the following:

1. As per guidelines of IS 456:2000
2. As mentioned in the customer specification of the project specified

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 workability	Slump in mm with Standard Cone as per IS: 1199		Use for which concrete is suitable
	Min.	Max.	
Very low	0	25	Large Mass concrete structure with heavy compaction equipment, 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 (including cover blocks)	- 12 mm
Reinforced concrete Except foundation	- 20 mm
Ordinary Plain concrete and Reinforced concrete foundation	- 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 equipment for concrete shall be well maintained and thoroughly cleaned before, commencement of concrete mixing. Such equipment 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. Moldings, 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, HCRM 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 **optimized** 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 manufacturer’s 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 manufacturer's 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 test 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), standard consist--ency, 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. TheEngineer and Contractor will jointly associate themselves with the tests irr--espective 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 SP 23 : Handbook on Concrete Mixes.

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 design mix , 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 up to 500 sqcm in cross section;
ii) Opening up to 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. If reinforcement steel issued is by BHEL to the contractor for use in reinforcement steel work, the unit rate shall include stacking of cut pieces/ scrap steel generated out of reinforcement steel work as per size (dia) for easy retrieval for further use.

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.

e) 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.

SECTION – C: 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 manufacturer's 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 lavers 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 under bed.

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 fiber 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) Fiber base self-finished felt, type 2, grade 2.

4) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)

5) Fiber 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 fiber 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) Fiber-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 ASTMC836-89a 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), alkalies 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 consists 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 are 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 leas 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 labour, 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.

SECTION – D: 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 foundary 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, than 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 consists 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 then ±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 wire 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.

2.03.02Barbed Wire Fencing

The barbed wire shall be conform to IS:278 latest edition. The barded 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 then 13mm and not more than 18mm. The distance between two barbs shall be 75±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 then 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:278Specification for Galvanised Steel Barbed wire for fencing.

IS:816Code of practice for use of Metal Arc welding for general construction in mild steel.

IS:1367Industrial Fasteners – Threaded steel fasteners - Technical supply condition.

IS:2721Specification for Galvanised Steel Chain Link fence fabric.

IS:2812Arc 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.

SECTION – E 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 painters 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 snellac, 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 liters 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 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 pretreated 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 pretreated 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 equipment 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 manufacturer's 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 conform 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 Code of Practice for painting of ferrous metal in buildings (Parts I & II)

IS: 2338 Code of Practice for finishing of wood and wood based materials (Parts I & II)

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.

SECTION – F: 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 be 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.
Sulpher	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 required adjustment in the size of the 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) n 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,:Manufacturer's certificate, dimension checks,

Nuts & Washers 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 advise 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 bidders 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 pe

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 bidders 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.

SECTION – G: ERECTION OF STRUCTURAL STEEL WORK

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 center 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, leveling, 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 equipment. 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) for bolt class 8.8 of IS:1367	Torque to be applied (Kg.M)
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 downgraded 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 flow ability 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	± 3.0 mm
	ii) In lateral direction	± 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	± 3.5 mm from true vertical
	Ii) For a column greater than 10M but less than 40M height	± 3.5 mm from true vertical for any 10 M length measured between connection levels, but not more than ±7 mm per 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	± 3.0 mm deviation of any bearing or

		resting level from levels shown in drawings.
	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 from vertical plane running through centre of bottom chord whichever is the least.	1/1500 of the span or greater than 10mm of upper chord member
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 whichever is the least
Crane Girders	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°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 equipment 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.

SECTION – H: SITE LEVELLING AND GRADING

1.00 GENERAL

This specification cover 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 include supplying and providing all labour, materials, supervision, services, equipment, 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, equipment 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 are required under statutory labour regulations, materials, equipment, 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 include all type of soil including laterite, murum etc with/without any percentage of kankars 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 include 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, murum 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 equipment 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 up to 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 chiseling 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 license from the District Authorities for undertaking the blasting work as well as for obtaining and storing the explosives as per Explosives Rules, 1940 corrected up to 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 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 shall any person 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 utilised as and when required and as directed by the engineer. The cost of complete item of earthwork includes the cost of re-handling 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 tonne 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 equipment 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 equipment 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 equipment, 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 are 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 **roughened** 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 are 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 labor, men, materials, equipment, 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.

SECTION – I: SPECIAL CIVIL ITEMS FOR NDCT SHELL

1.00 GENERAL

This specification covers the specifications for special items particular to Natural Draught Cooling Towers (NDCT) that are not covered in the earlier sections.

2.0 SHELL FORMWORK & SCAFFOLDING (JUMPFORM)

2.1 GENERAL

The formwork for the hyperboloid shell should be climbing and comprising a number of such climbing units on the inside and outside of the shell. The form shall be of plywood sheets with rigid frames. All component parts of formwork shall be so held that there shall be no deformation of the form. Necessary working platform with railing shall be provided. The system should satisfactorily work while dismantling the shuttering and thereafter climbing and aligning the form for the next lift. Tubular steel scaffolding should only be used. Rigid checking of the shuttering system shall be carried out before concreting. Post concreting checks shall also be made. Lifts shall be so arranged that the horizontal construction joints at the tower shell are maintained at a uniform spacing throughout the height of the tower shell so as to have a uniform appearance and well produced aesthetically good surface. The supervision, setting out, checking and shuttering system for the shell construction should be primarily intended to produce a smooth surface without geometrical discontinuities and shall achieve a high degree of dimensional accuracy.

Jump formwork calculation shall be submitted for review and approval. Before commencement of jumpform operation at site,the system should undergo approved third party inspection and approval thereon as far as safety of jump form system is concerned. Job safety analysis for complete system is to be carried out.

2.2 SETTING OUT

During construction, the setting out of the shuttering should be checked or controlled by the use of curved sweeps adjusted to the appropriate curvature and by batter rules set to the appropriate slope, making due allowance for any deflection of shutter panel and support likely to occur during the constructional operations.

2.3 TOLERANCES

The shell should be constructed within the following dimensional tolerances:

a. The shell wall centre line in horizontal plane measured radially at mid-point on a 3 m wide chord: ±15 mm.

b. The shell wall centreline considered in the meridional plane: ±10 mm rotation measured over a height of 1 m.

c. Thickness of the shell: (+) 10 mm (-) 5 mm locally at positions of shutter overlaps (these tolerances may be exceeded by agreement between the bidder and the Engineer-in-Charge).

d. Horizontal radius of shell at any section other than shell base: ±50 mm.

e. Horizontal radius at shell base: ±40 mm.

2.4 CHECKING THE SHELL

Survey of the geometry of the shell should be carried out from established stations on the ground arranged at not more than 10^{o} plan angle apart. Readings of horizontal radius shall be taken at every 6m height or weekly whichever is the more frequent. The shell position shall be within ±50 mm, except as limited by the relevant clause above. In assessing the measured values, the following allowances for survey inaccuracies shall be permitted. The allowable / tolerances shall be as follows:

For readings taken between shell heights of 0 m & 30 m at 6 m intervals : + 15 mm
For readings taken between shell heights of 30 m & 60 m : + 40 mm
For readings taken between shell heights of 60 m to 120 m : + 60 mm
For readings taken for shell heights above 120 m : + 80 mm

2.5 ADJUSTMENTS TO SHELL

Adjustment to the shell line shall be made from the survey results gradually, limiting the maximum change of direction from the existing vertical shell profile to not more than an angular change of 10 mm measured over 1 M of height. If this is impractical, a detailed corrected schedule shall be prepared and agreed, using larger values, in order to produce a smooth profile.

2.6 ACCEPTANCE OF DEVIATIONS FROM THE DESIGN SHELL GEOMETRY

In the case of non-compliance from the design shell geometry, contractor shall calculate the effect of these deviations on the shell and support column stresses and justify any decision to proceed with construction.

3.0 ACCESS DOOR IN SHELL

3.1 SUPPLY & INSTALLATION

The work shall comprise supplying and installing HDG Steel / FRP aluminium doors, complete with frames, fittings, fixtures, locks with duplicate set of keys and all necessary hardware as a complete package. Heavy-duty door closers shall also be supplied and installed on the doors. In general, the work shall conform to IS: 1081 and IS: 1948, latest editions, and / or any other relevant Indian Standard Codes.

3.2 TYPE OF DOOR

The doors shall be double plate flush doors and of hollow metal construction 45 mm thick. Door skin plates and stiffness shall have a minimum 3 mm thickness. The doors shall be insulated with mineral wool insulation for sound deadening. Doors shall present the same appearance on both sides. They shall be mortised for hinges and locks. Hollow flush doors shall be the product of reputed manufacturer regularly engaged in the fabrication of the products Door specification, except that minor variation due to differences in manufacturer's standards will be permitted case-by-case.

3.3 HDG STEEL / FRP DOORS

In case of HDG Steel doors single sheet of 18 G with suitable stiffeners duly hot dip galvanized shall be used. The galvanization shall not be less than 610 gm / sq.m. as per IS: 4759. Similarly in case of

aluminium / FRP doors, frames, necessary frame reinforcements and all other accessories shall be included in the work. All fixtures shall be factory installed wherever possible. All materials shall be from reputed and approved manufacturers.

3.4 ALUMINIUM DOORS

Aluminium doors shall be of section extruded from commercial quality aluminium alloy conforming to IS designation HE9-WP of IS 733 Specifications for wrought Aluminium and Aluminium alloys. Bars, Rods, and sections (for General Engineering purposes). Screw threads of machine screws used in the manufacture of aluminium doors shall conform to the requirements IS: 1362. Door sections, stiles and rails shall be not less than 35 mm in depth. No member shall be less than 3 mm in thickness. Frames shall be square and flat and the sections shall be cut to length, mitered and welded at the corners and all surplus metal removed. Other joints may be tenon-joined or welded. All frames shall have corners welded to a true right angle. The size of the frames shall not vary by more than + 1.5 mm for the sizes shown on the approved drawings. Hardware for the doors shall be aluminium or chrome-plated bronze to match surrounding work. The frames and doors shall be supplied in mat finish at all exposed surfaces and shall additionally be anodized 0.0006 inch thickness, satin finished in natural aluminium colour before shipment, all members shall be cleaned, etched and given a protective coating of clear, water-while methacrylate - type lacquer, resistant alkaline mortar.

Aluminium hollow flush doors shall be constructed in two sheets with internal bracings channels spot-welded to each inside face of the door, running the full height or width of the door and suitably spaced. Bracing channels may be spot-welded to one sheet with the other sheet projection welded to the bracings from the outside. Top and bottom of the door shall be closed and reinforced by channel member running full width of the door. All sections shall be extruded from aluminium alloy. Both edges of the doors shall be joined and reinforced the full height by continuous strip of a heavy gauge aluminium plate with off sets at hinge locations, on each edge of the door shall be reinforced by a channel of not less than No. 16 gauge running the full height of the door. Door edges or edge joints shall be welded full length and ground smooth. Insulating material shall be inserted between the vertical channels extending full length. Frame shall be prepared for attachment of all required hardware. Jambs shall be mortised for hinges and lock strike. Lock strike mortises shall permit horizontal adjustment of strike.

Portions of aluminium frames which come in contact with masonry construction shall, before shipment from the factory, be protected with a heavy coat of alkali-resistant bituminous paint. Aluminium coming in contact with other incompatible metals shall be coated with Zinc chromate primer. 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 brazed by such methods as will produce 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 edges of doors. Field connections of all work may be made with concealed screws or other approved type of fasteners, or may be welded as above. All drilling of structural supports to install aluminium doors and frames, shall be done and included in the work. All work shall be adequately braced and reinforced, as necessary, for strength and rigidity.

3.5 HARDWARE & FIXTURES

All door hardware shall be provided as necessary. All hardware shall be heavy duty and the door closer of extra heavy-duty type. The door closer shall be surface mounted and highest quality

suitable for use at external doors in a corrosive atmosphere and for high draft condition. The closer shall allow easy opening of the door, with high closing speed and quite firm action at latching. They shall be from reputed manufacturer, hydraulically controlled and full rack and pinion latch speed and back check control. The spring power must be adjustable to take care of use on external doors and draft condition. Necessary arms, brackets and other accessories must be available to suit the approved job conditions. The closer shall be painted in architecture aluminium hard coat of approved finish. All locks shall be cylinder type. The hardware and fixtures shall be approved by the Engineer-in-Charge-in-Charge before installation.

3.6 TRANSPORTING

All aluminium doors and frames shall be packed and created properly before dispatch, to ensure that there will be no damage to the fabricated materials. Loading shall be done with all care, to ensure safe arrival of the materials at site in an undamaged condition.

3.7 INSTALLATION

Doors and frames shall be installed plumb and true. Assembly and installation shall be done in accordance with the manufacturer's instruction. Frames shall be rigidly attached to the structure. All hardware shall be installed, adjusted and placed in perfect operation condition. Doors and frames not properly installed or being out of line or disturbed shall be reset and corrected by the Contractor at his expense.

4.0 PAINTING ON METAL SURFACES

All surfaces to be painted shall be cleaned by wire brushing and air blowing, shot blasting, etc. unless otherwise specified.

4.1 Surfaces of Stainless Steel, galvanized steel, gun-mental, bronze, brass items shall not be painted.

4.2 All MS parts (non-galvanised) shall be shop painted with ‘Red Oxide Zinc Chromate’ primer.

4.3 All welds shall be thoroughly cleaned and painted with 2 coats of Zinc rich paint of total dry film thickness of minimum 200 DFT.

4.4 Slide/Stop Log gate shall be coated with sealed zinc spray conforming to Table – 3, Part – 8 of BS: 5493 for life of more than 20 years.

4.5 MS PIPES & ACCESSORIES
4.5.1 Over Ground Piping

The external surfaces of pipe and its accessories such as Butterfly valves, flanges, etc. shall be painted with epoxy paint.

4.5.1.1 Surface preparation

Before painting, all the external surfaces of pipes shall be thoroughly cleaned of paints, rust, scales, grease, lose or disintegrated concrete or such other materials as are likely to impair the bond with

surface to be painted using scrappers and wire brushes to give a shining metallic surface. Then the pipes and accessories shall be cleaned by chemical washing initially by means of surface washing with diluted acid and finally with water. The surface so cleaned shall be washed with water and allowed to dry. A metal cleaning solution of approved make shall then be applied over it. After it is dried, the surface shall be again washed with water, scrapping with wire brushes simultaneously. An ample use of water is necessary at this stage to ensure that the metal cleaning solution is completely removed.

4.5.1.2 Application of Paint

After cleaning the surface, on coat of epoxy-based primer of approved make shall be applied on dry surface. After application of primer coat as above and before laying of pipes in position, the surface shall be applied with sealing coat and one finish coat of epoxy based paint of approved make having total dry film thickness of not less than 300 microns as per manufacturer's specification. Curing shall be carried out as per manufacturer's recommendations.

4.5.1.3 Testing
Coating thickness shall be measured by an electrometer or other standard measuring devices for measuring film thickness of finished paint. If the thickness is found to be less than specified, the pipes shall be re-surfaced to bring the same to specified thickness.

Test to determine the adhesion shall be carried out by driving a sharp wood chisel through the coating while holding it almost flat on the coating surface. A coating shall be considered adequately bonded if considerable force is required to lift the film and if the portion of the film remains in the valleys of sand blast pattern.

4.5.2 Underground Piping (if applicable)

Painting of exposed surfaces of pipes and accessories shall be as specified for over ground piping.
External protection of underground pipe shall be as under:

4.5.2.1 Surface Preparation

Shall be as same of specified for over ground piping.

4.5.2.2 Application of Paint

Single spiral wrap of fiberglass 'RP Tissue' shall be applied over the first coat of coal-tar enamel prior to its setting, spirally around the pipe overlapping at least 20 mm and pulled into the wet second coating to conform closely to the contour of the pipe. It shall be ensured that the fiberglass is impregnated in the primer coat.

After the first coat of coal-tar enamel has dried for a minimum of twenty four (24) hours a second coat of minimum thickness of 1.2 mm of coal-tar enamel (Shalimastic 4CTB or approved equal) shall be applied again without thinning completely over the fibre glass wrap.

A second coat of coal-tar enamel (Shalimastic 4CTB or equivalent) shall be applied by brush over the first primer coat maintaining minimum thickness of 1.5 mm. Before the first primer coat is dried a single spiral wrap of fiberglass 'RP Tissue' shall be applied over the first coat of coal-tar enamel prior

to its setting spirally around the pipe overlapping at least 20 mm and pulled into the wet second coating to conform closely to the contour of the pipe. It shall be ensured that the fiberglass is impregnated in the primer coat.

The coal-tar enamel coverage shall not be greater than 1.75 sq.m. per litre. The total thickness of the coating shall not be less than 2.5 mm. The thickness of pipe coating shall be measured either by electrometer or by coating thickness gauge.

5.0 PAINTING ON CONCRETE SURFACES

The internal surface of the tower basin, shell and fill support columns shall be painted with one coat of primer and two coats of water proof bituminous paint conforming to IS:3384 and IS:9862 respectively. External surface of the shell shall be painted with two coats of waterproof cement paint. All surfaces coming in contact with water and also subject to the alternate dry and wet conditions shall be given similar treatment. Before painting, the surfaces shall be brushed down and painted in a manner approved by and satisfactory to the Engineer-in-Charge-in-Charge. No painting shall be done when the concrete is still green, only such paint as can stand up to this condition shall be used, subject, however, to the approval of the Engineer-in-Charge-in-charge. Three coats of rust and corrosion resisting paint shall be applied after thorough cleaning of the surfaces, to steel work, including pipes unless otherwise specified, both inside and outside.

5.1 BITUMINOUS OR TAR COATING

The surface to be water-proofed shall be rendered absolutely dry, clean and dust free. The surface shall be papered, cleaned and completely coated with hot coal tar pitch of approved manufacture and quality, as per IS : 216 (not headed above 375^{o}F) using not less than 2 Kg./Sq.m. or with hot asphalt, i.e. bitumen according to IS:73 (not heated above 400^{o}F) using not less than 1.5 Kg./Sq.m. When the first coat is completely dried up and approved by the Engineer-in-Charge-in-Charge, the second coat shall be applied in the same manner using not less than 1.25 Kg./Sq.m. in case of coal tar and 1 Kg./Sq.m. in case of asphalt. Immediately after application of the second coat and before it is dried up sand shall be spread on the surface to cover it completely. Sufficient time shall be allowed after spreading of sand before back filling is done in order to allow the final coat to dry up completely.

6.0 WATER STOPS

6.1 PVC WATER STOPS

All the water stops shall be supplied and fixed by the Contractor. The minimum thickness of PVC ribbed water stops with central bulb shall be 10 mm and minimum width shall be 250 mm. At joints, the strips shall be lapped 75 mm and brazed or welded as the case may be. Brazing or welding PVC water stops shall be carried out by qualified welders / personnel and shall be subject to non-destructive testing by the Engineer-in-Charge. If necessary, dye-penetration test shall also be considered. The Contractor shall take particular care during installation in the case of water retaining structures water stops of approved material shall be provided if so specified on the drawing or desired by the Engineer-in-Charge-in-Charge of PVC water stop and ensure that the Centre line of water stop coincides with the joint centre lines and that concrete around the water stop is thoroughly compacted to achieve maximum density. Splicing of water stops shall be as per manufacturer's specifications and during splicing operation, care shall be taken to ensure that the water stops are not damaged.

7.0 LETTERING

7.1 LETTERING ON COOLING TOWER

The word 'TSGENCO' or similar word shall be painted on the cooling tower at height specified by engineer-in-charge. Approximate height of the letters shall be 2m and the distance between two letters shall be approx. 13m. Lettering shall be done with approved colour synthetic enamel paint including preparation of surface and painting work of base area.

7.1 APPLICATION

The dimension of the letters and spacing shall be as ordered by engineer-in-charge. These shall be stenciled or drawn in pencil and got approved before painting. They shall be of uniform size and finished neatly. The edges shall be straight or in pleasant smooth curves. The thickness of the lettering shall be as approved by Engineer-in-charge. Lettering shall be vertical or slanting as required.

7.2 MEASUREMENTS

Measurements shall be taken in terms of the letter cm (the measurement relates to the vertical height of the lettering). The letter heights shall be measured correct to a cm.

Dots, dashes, punctuations or other similar marks or lines shall not be measured for payment.